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ZOOLOGY:

A Systematic Account of

THE GENERAL STRUCTURE, HABITS, INSTINCTS, AND USES

OF THE

PRINCIPAL FAMILIES OF THE ANIMAL KINGDOM.

BY

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CHAPTER VI.

OF THE CLASS OF FISHES.

515. The fourth and last class of the Vertebrated sub-kingdom, comprises the animals known as Fishes. These are destined to live altogether in the water; and this circumstance has impressed a peculiar character on their entire organization: but the most important differences which they present, when we compare them with the other Vertebrata, consist in the conformation of their apparatus for respiration and circulation. They have no lungs at any period of their lives; and they breathe by gills only. Their heart contains but two cavities; and receives only venous blood. This liquid, after having been brought into contact with oxygen, passes into a dorsal vessel, where no new force accelerates its course through the different parts of the body. Their circulation cannot, therefore, be as active as among the higher animals; and their blood is cold like that of Reptiles. Their skin is covered only with scales, which, in some instances, are scarcely discoverable, so that the skin appears quite bare; they have no mammary glands like the Mammalia, and they are reproduced by means of eggs; lastly, their members have the form of fins.

516. The external form of Fishes varies; but their body is generally but little divided. Their head, which is as broad as the trunk, is not separated from it by any narrowing like the neck of the higher Vertebrata; and their tail, by its size at its origin, is not distinguished from the rest of the body. Some of these animals are quite destitute of fins; but in general we find a considerable number of these organs, placed,—some on the central line of the back or the abdomen, and consequently single, —others on the sides, and arranged in pairs (Fig. 245). These last represent the four limbs of the other Vertebrated animals.

The anterior members, which correspond with the arms of Man and the wings of Birds, are fixed on each side of the trunk, immediately behind the head, and are called *pectoral fins.* The abdominal members are less separated from each other, and are generally found on the lower side of the body; they may be situated more or less forwards or backwards, from the under part of the throat to the commencement of the tail; these are called *ventral fins.* The single fins occupy, as we have already said, the central line of the body; and are divided into *dorsal fins*, *anal fins*, and *caudal fins*, according as they are placed along the back, under the tail, or at its extremity. They have all very nearly the same structure, and consist almost always of a fold of skin, supported by bony or cartilaginous rays; very nearly in the same manner as the wings of bats and dragons are sustained by the fingers or by the ribs, of the animals.

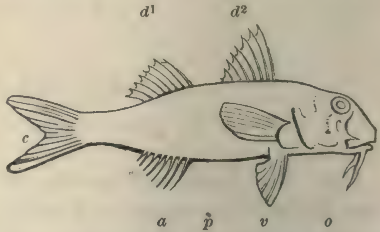


FIG. 245.—BEARDED MULLET, showing position of fins; *p*, pectoral fin; *v*, ventral fin; d^1, first dorsal; d^2, second dorsal; *c*, caudal; *a*, anal; *o*, opening of gill-covers.

517. On the external surface of the body, large openings are seen on each side; which are placed immediately behind the head, and which serve as an outlet for the water that has passed through the gills. In general there is only one on each side; and its anterior edge is moveable, and resembles a flap or valve. There exists on each side, along the whole length of the body, a series of pores, which is termed the *lateral line;* these are the openings of glands imbedded in the skin, by which the thick mucus is secreted, that covers the skin of Fishes, and gives to it its peculiar slipperiness.

518. The skin is sometimes almost entirely bare, but it is generally covered with scales. Occasionally these scales have the appearance of coarse grains, at other times they exist as large tubercles or plates of a considerable thickness; but in general

they present the aspect of very thin laminæ or plates, arranged in the manner of tiles upon a roof, and held together in the folds of the skin. We may compare them to our nails; but they contain a much larger quantity of calcareous salts. The colours with which these animals are adorned, astonish us by their variety and splendour. Sometimes they can only be compared to the most brilliant gold and silver; sometimes these present tints of the richest green, blue, red, or the deepest black. The silvery matter, which frequently gives to them so beautiful a metallic splendour, is secreted by the skin, and is composed of a number of small polished laminæ.

519. The Skeleton of Fishes is usually bony; but amongst several of these animals, such as the Ray and the Shark, it remains permanently in a fibro-cartilaginous or cartilaginous state; and there are even some in which this frame-work possesses still less solidity, and remains perfectly membranous: certain Lampreys are in this condition; and in this manner they form a transition between the Vertebrated and Invertebrated animals.—The bones never have any medullary canal; and the cartilage which constitutes their foundation is not the same as that of the Mammalia and Birds; for, when boiled in water, it does not give out any gelatine.

520. The skeleton is composed of the head, to which is

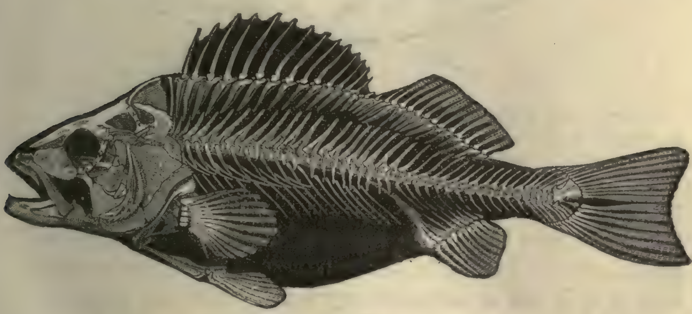


FIG. 246.—SKELETON OF THE PERCH.

joined a highly-developed apparatus which is subservient to

respiration; of the trunk; and of the members.—The structure of the head is very complicated. At first is seen a central or median portion, composed of a great number of bones united together by sutures, and forming a kind of immoveable keel, with which are connected the bones of the jaw, the cheeks, &c. This median portion, of which the general form is very nearly that of a pyramid with three sides, having its summit directed forwards, has at its back part the cavity of the cranium; in which is placed the apparatus for hearing, as well as the brain. Its middle side is hollowed out to form the orbital cavities, *or;* and in front are seen the apertures belonging to the olfactory apparatus, *n;* and a kind of large knob, formed by the vomer, and serving to support the upper jaw (Fig. 247.) We may distinguish the bones corresponding with the occipital, the temporal, the sphenoid, the parietal, the frontal, the ethmoid, and the vomer; but most of these are composed of several pieces, which never acquire the union that takes place at an early period among the Mammalia and Birds.—At the anterior extremity of

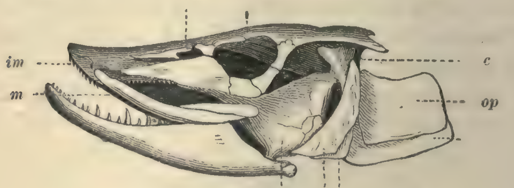


FIG. 247.—Bones of the head of Pike; *c*, cranium; *or*, orbit; *n*, nasal cavities; *im*, intermaxillary bone; *m*, superior maxillary bone; *t*, lateral partition, separating gills from mouth; *p*, *io*, *op*, bones of operculum, or gill-cover.

this cranial portion of the head is placed the upper-jaw, which is sometimes fixed there in an immoveable manner, but in general preserves great freedom of motion; there may be distinguished in it on each side an intermaxillary bone, placed near the medial line, and a maxillary bone, which extends sideways, and which is moveable upon the first.

521. A chain of small bony pieces extends on each side, from

the anterior angle of the orbital cavity to its posterior angle, and thus completes the circle of the orbit. Further inwards is seen also on each side a kind of vertical partition, (Fig. 247 *t*,) which is suspended to the skull, and which separates the orbits and the cheeks from the mouth. It is formed by bones corresponding with the palatine, pteregoid, and tympanic bones of

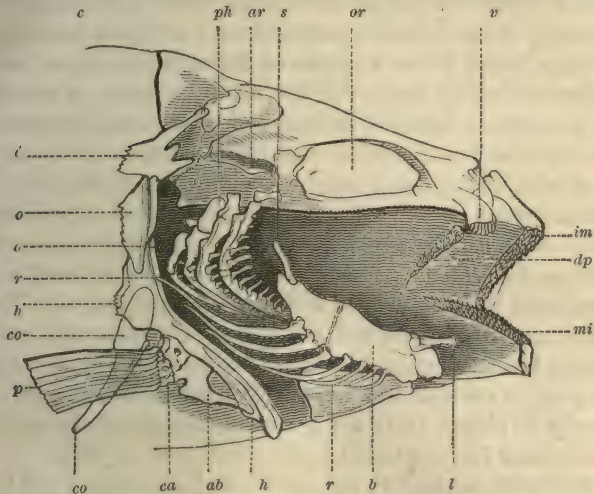


FIG. 248.—Bones of the head of the Perch, after the removal of the jaws, lateral partition, and operculum, on one side, to show the interior of the mouth, and the hyoid apparatus; *c*, cranium; *or*, orbit; *v*, vomer (armed with teeth); *im*, superior maxillary; *dp*, teeth implanted on the palatine arch; *mi*, lower jaw; *l*, lingual bone; *b*, lateral branches of the hyoid apparatus; *s*, process for the attachment of these to the lateral partition; *r*, *r*, branchio-stegal rays; *a*, branchial arches; *ph*, superior pharyngeal bones; *ar*, articular surface by which the lateral partition is attached; *o* to *h*, bony framework supporting the pectoral fin, *p*; *o* and *o'*, scapula divided into two pieces; *h*, humerus; *ab*, bone of the fore-arm; *ca*, bone of the carpus; *co*, coracoid bone.

the higher Vertebrata. At its under part it gives attachment to the lower jaw; and behind it is prolonged in such a manner, as to form a kind of moveable flap, which protects the respiratory apparatus, and is termed the operculum or gill-cover. The lower-jaw is formed of three pieces on each side. Within the lateral partitions just described, and lying at the bottom of the mouth, is found a framework of very complicated structure,

which serves for the support and protection of the gills, and which appears to resemble the hyoid bone of higher animals enormously developed (Fig. 248.) The bone of the tongue, *l*, is continued backwards by a series of pieces on the central line; and is articulated on each side with a lateral branch of great length and thickness, which, by its opposite extremity, is suspended (as it were) to the internal face of the before-mentioned partition. These lateral branches, formed of several bones, carry at their lower border a series of flattened rays, *r*, *r*, curved backwards, which unite with the opercular bones to complete the walls of the branchial cavities, and which are known under the name of *branchio-stegal* rays. Behind these branches we meet with four pairs of bony arches, *a*, passing off from the central portion of the hyoid apparatus. These are first directed backwards; then they curve upwards and inwards; and at last they are fixed to the base of the cranium by a series of small connecting bones, *ph*, termed the superior pharyngeal. These arches support the gills, and are thence called *branchial arches*. Lastly, behind the last pair of these, at the entrance of the œsophagus, are seen two inferior pharyngeal bones; which are usually so placed, as to apply themselves against the superior pharyngeals just mentioned.

522. Such is generally the complicated structure of the bony head of Fishes. Some anomalies, however, are occasionally observed; thus amongst the Sword-fishes and some other allied species of Tunny, the upper jaw is prolonged, so as to constitute a kind of beak, like a spit or the blade of a sword; which serves these fish as a powerful weapon to attack the largest marine animals. We shall not dwell here on the comparison of the different pieces of which the head of Fishes is composed, with the bones of the head of the Mammalia; as there still exists much uncertainty on this point.

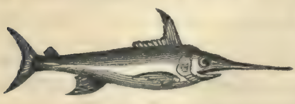


FIG. 249.—SWORD-FISH.

523. The vertebral column, which immediately follows the head, only presents two distinct portions, the one dorsal, the

other caudal (Fig. 246); for here there is neither neck nor sacrum. The body of the vertebræ has a peculiar form, being hollowed before and behind into a conical cavity; these two cavities sometimes unite in such a manner, as to form a continuous passage; and the double conical cavity, which is formed when two vertebræ are placed together, is filled with a soft substance. The ring destined for the passage of the spinal marrow is surmounted by a spinous process; and on each side there is generally seen a transverse process more or less distinct, which, beneath the abdominal cavity, extends outwards, and is usually united with the corresponding rib; but which, in the caudal portion of the column, is directed downwards, and often forms with that of the opposite side a ring, from the lower part of which arises a long and spinous process, similar to that which is situated on the dorsal side of the vertebræ.—The ribs are sometimes entirely absent; at other times they surround the abdomen, and amongst a small number of Fishes they are joined to a series of single bones, which ought to be considered a sternum. They often bear one or two pointed projections, which are directed outwards, and penetrate into the muscles. There are also, sometimes, similar processes, which spring from the bodies of the vertebræ; and it is thus that, in some tribes, such as amongst the Herrings, the small bones of Fishes become very numerous. Lastly, we find on the central line of the body a number of bones, termed *interspinous* (Fig. 250), which are usually applied against the extremities of the spinous processes of the vertebræ, and which articulate at their opposite ends with the rays of the median fins. These rays are sometimes pointed bones, which are then termed *spines:* but they are sometimes ossified only at their bases, the remainder being formed of a series of little cartilaginous pieces, jointed together; and often branch-

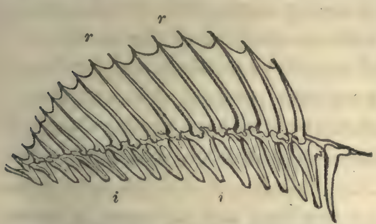


FIG. 250.—DORSAL FIN, supported on spiny rays, *r, r*, and these resting on interspinous bones, *i. i.*

ing at their summit; these are termed *articulated* or *soft rays;* the caudal fin is entirely formed of them (Fig. 246); and sometimes there are no others.

524. The lateral fins, which represent the members, are terminated by rays similar to those of the vertical fins, and analogous to the fingers. In the pectoral fin are seen, at the base of these appendages, a transverse series of four or five small bones (*c a*, Fig. 248), which are analogous to those of the carpus; and these, in their turns, are fixed to two flat bones, *a b*, which seem to be the radius and ulna widened. This apparatus is supported by a kind of bony girdle situated immediately behind the ears, on which the operculum or gill-cover is fixed; and it consists of three bones, extending from the cranium to the hyoid apparatus, and prolonged backwards into a pointed process. The principal piece which enters into its composition, is that which bears the fore-arm, and which may consequently be regarded as the humerus, *h;* it is united below with that of the opposite side and with the central prolongation of the hyoid apparatus; and it is connected with the cranium by two bones (*ǫ*, *o*), which are regarded by Cuvier as analogous to the scapula; and lastly, the pointed process which is prolonged over the sides of the body, is ordinarily formed of two pieces, and may be compared to the coracoid bone, *co.*—The posterior member is less complicated; the rays of the ventral fin are only supported on a single bone, usually of triangular form, which is frequently attached to the central portion of the osseous girdle of the anterior member, and which, in other instances, is merely suspended by the muscles, having no bony connexion with the skeleton of the trunk.

525. In *Cartilaginous* fishes, such as the Rays and the Sharks (of which the Dog-fish is a common species), the arrangement of the skeleton differs from that which we have already described, and exhibits a great resemblance to that of the still cartilaginous skeleton of the Tadpole. The skull is not divided by sutures, and is only composed of a single piece; this, however, is formed in other respects very nearly like the skull of ordinary Fishes. The upper jaw is formed by pieces analogous to the palatine bones and the vomer; the maxillary and the intermaxillary do

not exist, and are only found in a rudimentary state, hidden under the skin. The lower jaw has in like manner only one piece on each side, and the opercular apparatus is generally altogether wanting. The vertebral column is sometimes chiefly formed of a single tube, pierced on each side for the passage of the nerves, but not divided into distinct vertebræ. The bodies of the vertebræ are also frequently pierced through, so that the gelatinous substance which fills up the intervals of these bones forms a continued line through the whole column. The arrangement of the bones of the shoulder, of the pelvis, and of the fins, varies. Lastly, the hyoidean apparatus which supports the gills is usually formed very nearly in the same manner as amongst ordinary fish; but in the lowest groups of this class (amongst the Lampreys for example) the branchial arches are absent.

526. The greater number of Fishes swim with great agility; we are told that the Salmon, for example, advances sometimes with a rapidity of twenty-six feet in a second, and travels in one hour the space of from twenty to twenty-five miles. In general, it is through lateral strokes on the water, by the alternate bendings of the tail and the body, that they can move in this manner; and the muscles which are destined to bend the vertebral column laterally, are so developed, that they usually constitute the greatest part of the mass of the body. The fins on the central line, that is to say, the caudal, the dorsal, and the anal, serve to increase the extent of this kind of oar: but the lateral fins—the pectoral and the ventral—act but little in *progression*, or forward movement; and their principal use is generally to influence the *direction* of the course, and especially to support the animal in equilibrium.

527. A peculiarity in the organisation of Fishes, which is a great assistance to them in swimming, is the existence of a kind of bag filled with air, and constructed in such a manner as to be capable of being compressed at will. This *swimming bladder* is situated in the abdomen, and under the dorsal spine; and it usually communicates with the œsophagus, or with the stomach, by a canal, through which the air contained in its interior can escape; but this fluid does not appear to penetrate into it by

this passage, for it rather seems to be the product of a secretion, having its seat in a glandular portion of the walls of the reservoir itself; and sometimes this is completely closed. By the movements of the ribs, this elastic vessel is more or less compressed; and, according to the space that it occupies, it gives to the body of the fish a specific gravity, equal, superior, or inferior, to that of the water; and thus enables it to remain in equilibrium, to descend, or to rise, in this liquid. It has been remarked that it is often absent, and that it is generally very small, in the species destined to swim at the bottom of the water, or even to bury themselves in the mud, such as the Rays, Soles, Turbots, and Eels.

528. Amongst a small number of Fishes, the pectoral fins have an extreme development, and thus permit the animal to support itself for some minutes in the air after it has leaped out of the water. The Dactylopterus affords an example of this construction. There are some, which, by crawling, or by repeated leaps, can advance upon the ground. Some have been mentioned which can climb trees; but these examples are very rare.

FIG. 251.—DACTYLOPTERUS, ONE OF THE FLYING FISH.

529. In treating of the organs for movement amongst Fishes, we must not omit to mention a very singular apparatus, which is seen in some of these animals, and which enables them to adhere with great firmness to foreign bodies. This is a flattened disc, which covers the upper part of the head, and which is composed of a certain number of cartilaginous and moveable plates, directed obliquely backwards (Fig. 252). The Fish of the genus *Echineis* are the only species which present this mode of organisation; and one of them, which lives in the Mediterranean and in the Atlantic, and which has been for a long time

FIG. 252.—SUCKING-DISC OF THE REMORA.

celebrated under the name of *Remora*, or Sucking-Fish, (Fig. 253) has been the subject of many amusing and absurd fables.

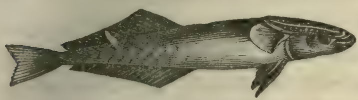


FIG. 253—REMORA.

It has been pretended that this small fish supports itself by a kind of suction through the disc just described; and the power of stopping a large vessel in rapid progress has been attributed to it. A species allied to the preceding is very common in the waters of the Isle of France; and it appears that, upon the coasts of Caffraria, it is employed in fishing, by allowing it to pursue fish, and then drawing it back, by means of a line attached to its tail, as soon as it has fastened itself upon its prey.

530. The life of a Fish is passed almost entirely in seeking its subsistence, and in flying from its enemies. Its external senses only appear to give it a few obtuse impressions; and its faculties are more or less limited. It shows no industry, nor any remarkable instinct; its brain is very slightly developed, and its organs of sense are very imperfect. The cavity of the skull is small compared to the size of the body; and the brain does not nearly occupy it. Between its sides and the brain is found a spongy and fatty mass of a considerable size, particularly in adult individuals. The lobes which compose the brain are placed in a row, one behind the other; in front we see the olfactive ganglia, *ol*, often separated from the rest by a peduncle or foot-stalk; next the cerebral hemispheres, *ch*; then the optic lobes, *op*, which are often larger than the preceding; then the cerebellum, *ce*; and, behind all these parts, the lobes belonging to the medulla oblongata, *sp*.

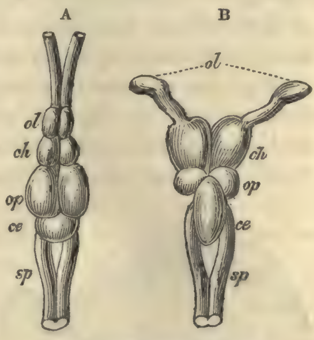


FIG. 254.—BRAINS OF FISHES.
A, Cod; B, Shark.

531. The nature of the integuments of Fish necessarily renders their sense of feeling very imperfect; and deprived as they are of prolonged members, and particularly of flexible fingers adapted to take hold of objects, it is only by means of their lips that they can exercise the sense of touch. The filaments which are often seen around the mouth, appear to inform them of the contact of bodies. The sense of taste must also be very nearly absent; for their tongue is scarcely moveable, and is not fleshy; it receives very few nerves, and the food never remains long in the mouth. The apparatus for smelling is of a much more complicated structure; but is not arranged so as to allow either air, or the water serving for respiration, to pass through it. The nasal fossa only consists of two cavities, closed at the back; each generally opens outwards by two nostrils, and is furnished by a pituitary membrane folded in a very remarkable manner. The ear is nearly always placed completely within the cavity of the skull, upon the sides of the brain; and simply consists of a vestibule surmounted by three semicircular canals, at which the sonorous undulations can only arrive after having put into vibration the common integuments and the bones of the cranium. In general we see nothing that can be compared to the external ear, to the membrana tympani, or to the drum. Lastly, the eyes are very large and nearly immoveable; they have no true eyelids, nor lachrymal apparatus. The skin is continued over the eye, and is thin enough to be traversed by the light. The cornea is almost flat; the pupil very large, and but little or not at all contractile; and the crystalline lens is spherical. These organs generally do not usually present any peculiarity as to their position; but amongst some fish there is a remarkable anomaly. Thus, amongst the Soles, Plaices, Turbots, and other flat-fish, they are not placed as usual on both sides of the head, but are both situated on the same side; and this kind of mon-

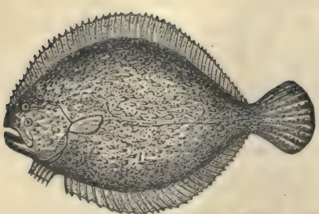


FIG. 255.—TURBOT.

strosity coincides with a defect of symmetry in other parts of the body.

532. Fishes are very voracious; there are only a few which live principally on vegetable matter; and generally they swallow without any selection all the small animals which come within their reach. Some species are destitute of teeth, but amongst the greatest part, they exist in several rows, as in the mouth of the Shark, for example; and they are more commonly found, not only in the two jaws, but also on the palate, implanted on the vomer and palatine bones,—on the tongue,—upon the interior edge of the branchial arches,—and even in the back of the mouth upon the pharyngeal bones, which surround the entrance of the œsophagus. They have never any roots, but are fixed to the bones which support them; they fall off nevertheless—probably by a mechanism analogous to that of the fall of the horns of the stag—and are replaced by new teeth, which arise sometimes beneath, sometimes by the side of the old ones. The teeth with which the jaws are armed, only serve, in general, to hold or to crush the prey; those situated at the bottom of the mouth are rarely (in existing fishes at least) disposed in such a manner as to reduce it. Their form varies very much; sometimes they are so fine and closely set, that they present the appearance of velvet; whilst in other instances they constitute strong hooks, plates with cutting edges, or rounded tubercles.

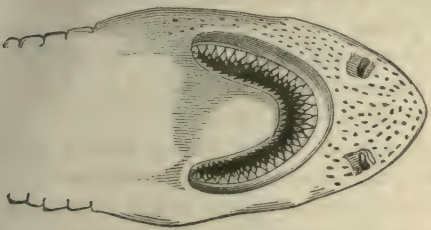


FIG. 256.—HEAD OF SHARK.

533. There are some Fish which are not supported on solid matter, and which live only by sucking the liquids which they draw from the bodies of other animals; the Lampreys are an example of this. Their mouth, instead of having the usual arrangement, presents a very singular structure, but one which is in complete accordance with its functions. The cartilages,

which amongst the Rays, &c. form the jaws, are here united into rings, and support a fleshy disc, the surface of which is furnished with teeth, whilst its centre is occupied by the mouth. The tongue also is supplied with teeth, and moves forwards and backwards like a piston; so that the animal can make use of this apparatus, either to fix itself upon another body, or to pump up the fluids on which it is supported.

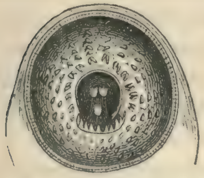


FIG. 257.—MOUTH OF THE LAMPREY.

534. The mouth is not surrounded by any salivary gland. The œsophagus is short; the stomach and the intestines vary in size and form. The liver is generally large, and of a soft tissue; the pancreas is nearly always replaced by peculiar cœcal appendages placed around the pylorus; the position of the anus varies much; sometimes it is found under the throat, at other times under the tail. The kidneys are extremely large, and extend themselves on both sides of the vertebral column, through the whole length of the abdomen. Their excretory passages end in a kind of bladder, whose external opening is placed immediately behind the anus and the orifice of the reproductive organs. The digestive process appears to be performed very rapidly; and the chyle is absorbed by numerous lymphatic vessels, which empty themselves by several trunks into the venous system near the heart.

535. The blood of Fishes, as already mentioned, is red; and the globules have an elliptical form, and are of considerable dimensions. The heart is placed under the throat, in a cavity divided from the abdomen by a kind of diaphragm, and protected by the pharyngeal bones above, by the branchial arches on the sides, and in general by the humeral girdle behind. It is composed of one auricle, which receives the venous blood collected into a large sinus situated in its neighbourhood; and of a ventricle placed beneath it, and giving rise at its anterior extremity to a pulmonary artery, which is swollen out at its origin into a contractile bulb. This vessel soon divides into lateral branches, which are distributed to the gills; and the blood, after having

traversed these organs, passes towards the head by another vessel, which in like manner runs along the edges of the branchial

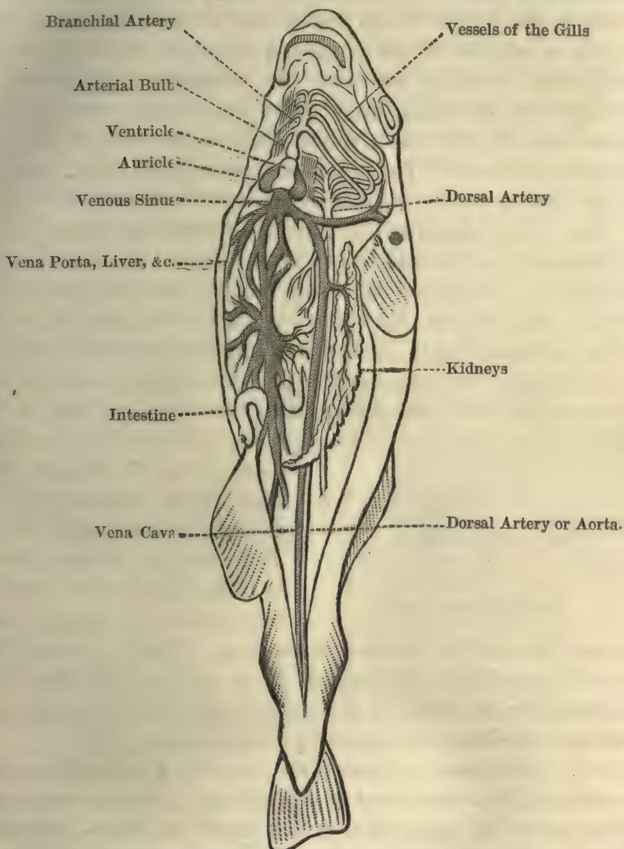


FIG. 258.—CIRCULATING APPARATUS OF FISH.

arches. These canals then send out some branches to the neighbouring parts, and are united together again to form a large dorsal artery, which passes backwards, beneath the vertebral column, and spreads its ramifications to all parts of the body.

Finally, the venous blood is not all directly returned into the sinus, which we have before mentioned; for that of the intestines and of some other parts, before being sent back into the heart, is distributed by the portal vein through the liver. We see, then, that the blood, in passing through the circle of the circulation, entirely traverses the respiratory apparatus, as amongst the Mammalia and Birds; but in this course it only passes once into the heart, which consequently renders its progress much slower. The heart itself corresponds in its functions to the right half of the same organ amongst the higher Vertebrata.

536. The Respiration of Fishes is effected by means of the air dissolved in the water; and takes place at the surface of a multitude of projecting and very vascular membranous plates, fixed on the external edge of the branchial arches, the position of which has been already pointed out. In general there are on either side four gills, each composed of two rows of lengthened plates. In several of the Cartilaginous fishes, there are five, and in the Lamprey we find seven. Amongst nearly all the Osseous fishes these plates are simple, and fixed at the bottom only; in a small number, such as the *Hippocampus*, commonly called Sea Horse, they are, on the contrary, ramified, and somewhat resemble bunches of feathers. Lastly, amongst the greater part of the Cartilaginous fishes, such as the Rays and Sharks, they are fixed to the skin by their external edges, as well as to the branchial arches by their internal.

FIG. 259.—HIPPOCAMPUS.

537. The water necessary for respiration enters into the mouth, and by a movement of deglutition is forced through the openings which exist between the branchial arches, and thus arrives at the gills; after bathing the surface of these, it escapes outwards by the opening of the gills. We see, in fact, the animal alternately opening the mouth, and raising its operculum. Amongst those fish whose gills are free at their external edge, it is sufficient to have one of these openings on each side; but when the gills are fixed, it is necessary for the exit of the water to

have an opening for every one of the spaces between the gills. Thus, in the Shark we find five, and in the Lamprey (Fig. 285) seven pairs. We can therefore know the arrangement of the respiratory apparatus, by the single inspection of its external openings. It is also observed that amongst some fishes, the water does not pass directly from the mouth into the respiratory cavity by the openings situated between the branchial arches, but arrives there by a canal situated beneath the œsophagus, something like the trachea of the higher animals; the Lampreys show this kind of structure.

538. Fish consume but a small quantity of oxygen; some, however, are not satisfied with that which is dissolved in the water, and come to the surface from time to time to breathe air. There are even some which make use of it by swallowing it, and converting its oxygen into carbonic acid as it passes along the intestine; the Loach of our ponds shows us an example of this singular phenomenon. When fish remain out of the water, they die in general very quickly from asphyxia; not because they want oxygen; but because the branchial plates, being no longer supported by the water, fall together, and thus cannot so easily be traversed by the blood; and because these organs, when dried up, become unfitted to perform their functions. Thus, the fish that perish the most rapidly by exposure to the air have their gill-openings very wide, which facilitate the evaporation at the surface of the gills; whilst those which resist it the best, have very small apertures, or else possess some receptacle, where they can preserve sufficient water to moisten these organs. The different fish which compose the family of the Labyrinthiform Pharyngeans, are very remarkable in this respect, and owe their name to the cellular reservoirs of

FIG. 260.—RESPIRATORY APPARATUS OF ANABAS.

water placed above their gills. These reservoirs, situated under the operculum, and formed by the plates of the pharyngeal bones, effectually serve to retain a certain quantity of water, which keeps the gills moist when the animal is in the air, and enables it to live there for some time: hence these fish are accustomed to leave the rivers and ponds, which are their usual abode, and convey themselves to considerable distances by crawling in the grass or on the ground. Those which present this labyrinthiform apparatus in its highest degree of complication, and which have received the name of *Anabas*, not only

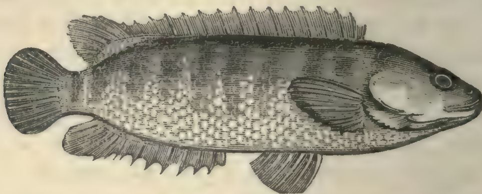


FIG. 261.—ANABAS.

remain very long out of the water, but can even, we are told, climb up trees. The greater part of the fishes of this family inhabit India, China, and the Moluccas. One species, the *Gourami*, which originally belonged to China, and which is much esteemed for its savoury flesh, has been naturalised in the ponds of the Isle of France and of Cayenne.

539. As already stated, Fishes produce scarcely any heat; that is, their temperature is usually but little above that of the medium they inhabit. The Tunny, Sword-fish, and their allies, however, constitute an exception to this rule; for they are able to sustain a fixed temperature of about 90°; and they are distinguished from other Fishes by the greater redness of their blood, which results from the larger proportion of red corpuscles. Several of this class have the singular power of developing Electricity, and of giving very strong shocks to the animals which touch them. The Torpedo, the Silurus or Malapterurus, and a species of Gymnotus, are thus constituted; and it is a remarkable thing that the electrical organ presents a very different conformation in each of them.

540. It is the *Gymnotus*, or Electric Eel, which possesses this curious power in the highest degree. It inhabits Southern America; and very much resembles ordinary Eels, except that it has no fins at the end of its tail, and that its skin is without any visible scales. This fish attains about six feet in length; its body is long, and of uniform size, and its skin is covered with a viscid matter. It is very common in the small streams and pools, which are met with here and there in the immense plains situated between the Cordilleras, the Orinoco, and the Banda-Orientalis of South America; and we find it also in the rivers Meta, Apure, and Orinoco.—The electric shocks which it gives at pleasure, and in any direction that it chooses, are sufficient to overcome men and horses; and the Gymnotus has recourse to this means to defend itself against its enemies, and to kill at a distance the fish that it wishes to eat; for water, as well as metals, transmits the benumbing shock of this singular animal,—in the same manner as lightning-conductors convey the electricity of the clouds from the atmosphere to the ground. Its first discharges are in general weak; but when it is irritated and agitated, they become stronger and stronger, and are then terrible. When it has thus struck repeated blows, it becomes exhausted, and requires rest, for a longer or shorter time, before it recovers its power of giving fresh shocks. We are told that it employs this time in reloading its electrical organs, and that the Americans profit by this circumstance to take it without danger. In order to do this, they drive wild horses into the ponds inhabited by these fish; which, receiving their first shocks, are soon stunned and overcome, or even killed; they then seize the exhausted Gymnoti with nets, or with harpoons.

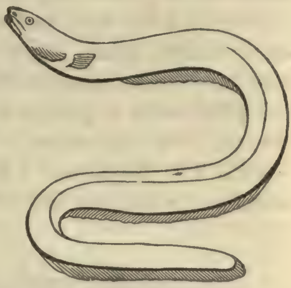


Fig. 262.—Gymnotus.

541. The apparatus by which the Gymnotus produces these disturbances lies along the back of the tail, and consists of

four longitudinal bundles, composed of a great number of parallel membranous plates very closely approaching each other; these are nearly horizontal, and are united by an infinite number of other smaller plates placed vertically throughout. The small prismatic and transverse cells formed by the union of these plates, are filled with a gelatinous matter; and the whole apparatus receives very large nerves.

542. The *Torpedo* is a flat cartilaginous fish, very much resembling the common Rays. Its body is smooth, and represents

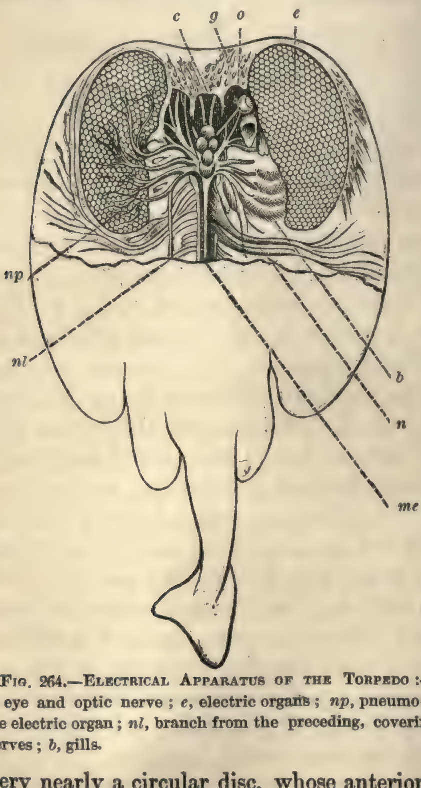


FIG. 263. —COMMON TORPEDO.

FIG. 264.—ELECTRICAL APPARATUS OF THE TORPEDO :—*c*, brain; *me*, spinal cord; *o*, eye and optic nerve; *e*, electric organs; *np*, pneumo-gastric nerves, proceeding to the electric organ; *nl*, branch from the preceding, covering the lateral nerve; *n*, spinal nerves; *b*, gills.

very nearly a circular disc, whose anterior border is formed by two prolongations of the snout, which go on each side to join

the pectoral fins; leaving between these organs, and the head and gills, an oval space, in which is placed the electrical apparatus of these fish. This apparatus is composed of a multitude of membranous vertical tubes, pressed one against the other, like the cells of bees, and subdivided by horizontal partitions into small cells filled with mucous matter; it is supplied by several very large branches of the pneumo-gastric nerves. It is in these singular organs that the electricity is produced, by which the Torpedo can give violent shocks to those who touch them, and produce the same phenomena which in physical experiments result from an ordinary electric current; such as sparks, chemical decompositions, &c. These fish are less powerful than the Gymnotus; but can nevertheless strike with sufficient force to benumb the arms of those who touch them; and it is probably by this means, that they seize their prey. It has been ascertained that this property is dependent on the posterior lobe of the Encephalon; and that by destroying this lobe, or by cutting the nerves which spring from it, the power of producing these shocks is destroyed. Several species exist in the seas which wash the shores of Europe.

543. The electrical *Silurus* or *Malapterurus* inhabits the Nile

FIG. 265.—ELECTRIC MALAPTERURUS.

and the Senegal; its length is from about ten to fourteen inches; and it appears to derive the power of giving electrical shocks from a particular tissue situated between the skin of the sides and the muscles, and having the appearance of a laminated cellular tissue. The Arabs give to this fish the name of *Raasch*, which signifies *thunder*.

544. Fishes multiply by means of eggs; and the number of these is sometimes immense, several hundred-thousands being often produced at a time. In general they have only a mucila-

ginous envelope, and are fertilized after they are laid. Some of these animals are, on the contrary, ovo-viviparous; but whatever may be the manner in which the young fish are brought into life, they are from the moment of their birth completely abandoned to themselves, and many of them perish during the early period of their existence. There are a few species, however, such as the *Gobies*, which make regular nests for their young, composed of sea-weed; and tend them with great care.

545. It is to the simultaneous development of an incalculable number of eggs deposited in the same place, and to the instinct which induces different fish to follow each other, that we are to attribute the union of certain species in immense and closely-packed legions, called by fishermen *shoals of fish*. We can hardly term these unions, *societies;* the individuals of which they are composed do not assist one another; the same wants to be satisfied keep them in the same locality, or remove them from it; and if we see them occasionally following an individual as a guide, it is probably the consequence of a tendency to imitation, which always accompanies the first dawnings of intelligence.

546. However it may be, these animals, thus united in troops, often make long journeys, sometimes to gain the sea, sometimes to ascend rivers or to change their climate. Certain fish lead an almost sedentary life, and remain always in the locality where they were produced; others are always wandering, and a great number of these animals periodically make journeys of greater or less length. At the time for spawning, they generally approach the coasts or enter the rivers; and in this manner they sometimes effect an extremely long passage. Every year, towards the same period, large numbers of migrating fish arrive in the same places; and it is generally believed that several of these species regularly migrate from the north towards the south, and from the south towards the north, following a determined route; but perhaps it would be more true to believe, that when they disappear from the shores, they only retire into the greater depths of the sea. The Herring is one of the most remarkable fishes in this respect, as well as the most celebrated on account of the importance of the fisheries of which

it is the object. It inhabits the northern seas, and arrives every year in innumerable legions upon different parts of the coasts of Europe, Asia, and America, but never descends below the 45th degree of north latitude. Some naturalists think that all these shoals of herrings periodically retire beneath the ice of the polar seas, and set out from this common retreat in an immense column, which, by subdividing itself, is spread out over nearly all the coasts situated above the parallel which we have mentioned. They have even gone so far as to trace upon the chart the journeyings of these shoals; but this long migration, and this common rendezvous in the arctic regions, are far from being demonstrated; and there is reason to believe that these events do not take place in this manner. It is very near our coasts that the herrings deposit their eggs, and it is probable that the young very soon retire into the depth of the sea, and there direct themselves towards the north, where they meet in great abundance with the small Crustacea and Animalculæ, which are fitted to serve them as food. In the spring, other wants bring them towards the shore, and cause them to seek shallower and warmer water. They collect themselves into immense shoals, and descend towards the south; but after having arrived in the Baltic, upon the coasts of Holland, and even as far as Brittany, we do not see them retake the route to the north, to pass the winter under the ice of the pole, and to recommence in the following spring their pretended periodical journey.

547. However this may be, in the months of April and May, Herrings begin to show themselves in the waters of the Isles of Shetland; and, towards the end of June and July, they arrive there in an incalculable number, forming large shoals, which sometimes cover the surface of the sea to an extent of several leagues, and which are several hundred feet in thickness. Soon afterwards, these fish are spread along the coasts of Scotland and England. During the months of September and October, they give place to larger fish; and from the middle of October until the end of the year, they abound on the north coast of France, principally from the Straits of Calais to the mouth of the Seine. In July and August, they generally remain in the

open sea; but they then come into shallower water, and seek a convenient place for laying their eggs, where they remain until towards the month of February. The older Herrings deposit their spawn the first, and the younger ones afterwards; but temperature and other circumstances also appear to have some influence on this phenomenon; for in particular localities, we find eggs during nearly the whole year. After this period they are thin and but little esteemed; fishermen then call them "shotten herrings." Their multiplication is prodigious; there have been found more than sixty thousand eggs in the abdomen of one single female of moderate size. We are told that their spawn sometimes covers the surface of the sea for a great extent, and at a distance appears very much as if saw-dust had been spread there. Very little is known of these fish at an early period.

548. The Pilchard, the Mackerel, the Tunny, and the Anchovy, are also Fish of passage, which periodically visit the coasts, and give rise there to important fisheries. The Salmon is equally remarkable for its voyages: it inhabits all the arctic seas, and every spring it enters the rivers in large numbers, and ascends nearly to their source. In these migrations the Salmon follow a regular order; forming into two long files united in front, and conducted by the largest female, who commences the march, whilst the smaller males form the rear-guard. These troops generally swim with a great noise in the middle of the stream, and near the surface of the water, if the temperature is mild, but nearer the bottom if the heat is great. In general the Salmon advance slowly and by leaping; but if some danger appears to threaten them, the rapidity of their swimming is so great, that the eye can hardly follow them. If a dyke or a cascade opposes their progress, they make the greatest efforts to overcome it. By supporting themselves against a rock, and violently bending their body in a bow, they throw themselves out of the water, and jump sometimes to a height of from 10 to 16 feet into the air, so as to fall again clear of the obstacle which impeded them. The Salmon thus ascend rivers nearly to their source; and then seek in the small streams and quiet places a

bottom of sand and gravel, fit to deposit their eggs. Afterwards, when thinned and weakened by so much fatigue, they descend in autumn to the mouth of the river, in order to pass their winter in the sea. The eggs are deposited in a hole, which the female digs in the sand. The male then comes to fertilise them. The young Salmon grow very quickly; and when they have attained to about the length of a foot, they leave the rivers to proceed to the sea, which they quit in turn to enter the streams, when they have attained the length of 16 or 18 inches, which is towards the middle of the summer that follows their birth. We have already seen that the Swallows, which at the approach of the cold season migrate towards the south, every year return into the same places. It appears that the Salmon has the same instinct. To ascertain this, a naturalist, named Deslandes, placed a ring of copper on the tail of twelve of these fish, and set them at liberty in the river Auzou, in Brittany. Soon afterwards they all disappeared; but the following year, five of these Salmon were caught in the same place; the second year, three; and the year after, three more.

549. The habits of Fish show but few curious peculiarities; but the history of these animals ought nevertheless to interest us, if only on account of the fisheries to which they give origin. At a period which is not very far removed from our own, this branch of industry occupied a fifth of the population of Holland; and for the herring-fishery alone, that country covered all the northern seas with its vessels. In England it has supported a considerable number of good and hardy sailors; and even in France, where it has less importance, there are computed to be thirty or forty thousand fishermen, of which nearly a third venture every year as far as Iceland and Newfoundland to seek for the Cod, a large and excellent fish, which abounds in those parts of the sea, and which is found also, in a comparatively small number, in our own seas.

Fig. 266.—Cod.

550. The classification of Fishes most generally received is that of Cuvier, who made this group his peculiar study. It is founded upon the condition of the skeleton, and upon the structure and arrangement of the fins. The first division of the class is into the *Osseous* and *Cartilaginous* Fishes; and this division has reference, not merely to the quantity of earthy matter in the skeleton, but to the number of pieces of which the jaws are composed. Although the Osseous Fishes are in many respects the most elevated in the scale, and have the most elaborately-constructed mouth, yet many of the Cartilaginous Fishes surpass them in the development of the cerebral hemispheres, which is probably to be regarded as a measure of their comparative intelligence (ANIM. PHYSIOL. § 452); and we find in many of the latter group, also, a curious modification of the reproductive apparatus, which enables the young animal to derive continued assistance from its parent. Yet it is in this group, also, that we find the very lowest members of the class, in which the vertebrated structure is almost completely lost sight of (§ 519). Thus we may regard the Osseous and Cartilaginous Fishes as forming two parallel series, neither of which can be regarded as above or below the other. Both are connected with the class of Reptiles by some very curious links.

551. The sub-class of Osseous Fishes is divided in the first instance into the groups ACANTHOPTERYGII, or *spiny-finned*, and MALACOPTERYGII, or *soft-finned*, Fishes. In the former, the first portion of the dorsal, or the first dorsal fin (when there are two) always have *spinous* rays (§ 523); of which there are also some in the anal, and at least one in each ventral. In the latter, all the rays, with the occasional exception of the first dorsal or the pectorals, are soft or jointed. The Acanthopterygii cannot be easily again subdivided, except into families; but the Malacopterygii may be divided into three orders, according to the position of the ventral fins. If these are situated under the abdomen, the fishes are *Abdominal;* if attached to the shoulder, they are *Sub-brachial;* and if wanting, they are *Apodal*. Each of these orders, especially the first, contains numerous families.

552. The sub-class of Cartilaginous Fishes is primarily

divided into those having the extremities of the gill-filaments unattached (as in Osseous Fishes); and those having them fixed. The former group constitutes but a single order; but the latter is again subdivided into those which have the jaws moveable and adapted for mastication; and those which have them soldered into a ring for suction. The latter are termed *Cyclostomi*, or circular-mouthed Fishes.

553. The following Table will perhaps enable this arrangement to be more easily understood. We shall presently find, however, that there are one or two small groups not included in it, which are separated from the rest by characters so remarkable, as perhaps to entitle them to be ranked as distinct orders.

OSSEOUS	*Acanthopterygii*, spiny-rayed		*Acanthopterygii.*
	Malacopterygii, soft-rayed	ventral fins beneath abdomen	*Abdominales.*
		ventral fins beneath shoulder	*Sub-brachiati.*
		without ventral fins	*Apoda.*
CARTILAGINOUS	gills free		*Sturiones.*
	gills fixed	jaws moveable	*Plagiostomi.*
		jaws soldered	*Cyclostomi.*

554. The class of Fishes is probably the most numerous of the whole Vertebrated series, both in regard to the number of families, genera, and species which it contains, and in regard to the number of individuals of the same species. The structure of a very large proportion of it has been but very imperfectly investigated; and of the habits of these animals still less is known. Instead, therefore, of giving a technical description of every family, such as will be found in Systematic Treatises on Zoology, we shall confine ourselves to a notice of those groups which are of most general interest, either on account of peculiarities in their structure, or their importance to Man. It has been calculated that, exclusive of lakes and rivers, the seas occupy full seven-tenths of the earth's surface. These seas yield food even to the depth of several hundred feet; and, as there is no obstacle in the water to bar the movements of Fish, we see that their pasture-grounds are almost unlimited in extent. Different tribes are formed to inhabit different situations; thus we have some Fish adapted to live in fresh-water only,—others

which can only live in salt-water,—and others, again, which can pass from the one to the other without inconvenience. Of fresh-water fishes, some are the inhabitants of rivers, others of lakes, whilst others prefer small streams. Of the marine fishes, some keep near the shore, whilst others pass most of their lives in the open sea; some, again, float near the surface; whilst others never rise much above the bottom. It is probable that we might regard the deeper parts of the ocean as divided (so to speak) into *strata*, each tenanted by certain species of fish; for it is quite certain, that there is a particular range of depth, in which each species is usually found, and beyond which it seldom strays, either towards the surface or the bottom of the ocean. It is among the Fishes of shallow waters, and those which habitually tenant the higher stratum of the deep seas, that we find the most beautiful display of colours; those of deep waters are for the most part comparatively dull in tint. This difference is probably due to the absence of light, which seems necessary to the development of the most brilliant colours; for the diminution in the intensity of the sun's rays, as they traverse water, is very rapid. What may be the absolute depth of water, at which all light ceases, and death and darkness reign, we have no direct means of ascertaining. It varies, of course, with the latitude; since, the more obliquely the sun's rays fall upon the water, the less will be the depth to which they will penetrate.

ORDER I.—ACANTHOPTERYGII.

555. Of this Order, one of the principal families is that of PERCIDÆ, or *Perches;* of which the common *Perch* of this country may be taken as an example. In this group, the body is oblong, and covered with hard or rough scales; and the opercular bone is edged with spines or small teeth, which do not, however, extend over the cheek. The Perch is one of our most common fresh-water fishes, abounding in rivers, lakes, and ponds, especially such as are clear, and lurking under the banks, or swimming near the surface. It is spread throughout the

whole of temperate Europe, and is even found in Lapland; other species are found in America, and in the tropical parts of the Old World. The food of the Perch consists of insects, worms, and small fishes, which it devours with great voracity; and it may be rendered sufficiently tame, to take these from the hand. Like the Carp, it is very tenacious of life; and will live for many hours if packed in wet moss, and occasionally refreshed with water. The *Basse* is a marine fish, nearly allied to the Perch in its general structure; it is found on the whole line of our southern coast; and associates in shoals, which at the spawning time frequent the mouths of rivers, and even advance up the stream to a considerable distance. It will not only live but thrive in fresh-water, if well supplied with food; which, in its natural haunts, consists of small fishes and crustaceans. In these, and other species, the ventral fins are placed immediately beneath the pectoral (Fig. 246); and Fish in which this arrangement exists, are characterised as *thoracic.*—Other Percidæ, however, have the ventrals situated upon the throat, further forward than the pectorals; such are said to be *jugular.* In this group we find the *Trachinus* or *Weever*, which has the first ray of the dorsal fin extended into a very long spine, and has also a strong spine on each operculum. This fish lies in the mud, and inflicts severe wounds with its dorsal spine, which the fishermen believe to have a poisonous power; the bad character of the wound, however, merely results from the rugged nature of the instrument which inflicts it. Something of the same kind is the case with the Perch; the sharp spines in its dorsal fin having been known to lacerate the fingers of those who handle them incautiously.—Another curious genus of this second group is the *Uranoscopus*, or Star-gazer; so called because the eyes are situated on the upper surface of the nearly cubical head, and directed towards the heavens. Within the mouth, behind the tongue, is a long narrow slip, which the fish can protrude; and which serves as a bait to attract the small fishes on which it preys, whilst it is itself concealed in the mud. One species inhabits the Mediterranean; but none of the others are eaten.—A third division of the Percidæ comprises those which are *abdominal*,

having the ventral fins behind the pectorals. This group includes the genus *Polynemus,* which is characterised by the very curious extension of the rays of the pectoral fins into long filaments, which hang loosely on each side of the body, being sometimes prolonged to twice its length, and giving it a very beautiful appearance. The fishes of this genus are found in the seas and rivers of tropical countries; they are usually very brilliant in their colours; and they are regarded as most delicious articles of food. The Mango-fish of the Ganges is a species of this genus; as is also the Suleah-fish of Bengal, to which attention has recently been directed, as affording in its air-bladder a large supply of excellent isinglass.—Besides the foregoing, there is a group of Percidæ, in which the ventral fins are placed still further backwards; these are for the most part marine fishes, some of them inhabiting our own coasts, and others of larger size being natives of tropical seas. Among the former is the *Mullus* or *Surmullet;* which has been in great repute among epicures from the time of the Romans, who used to feast their eyes upon the changes of colour which the Red Mullet undergoes in dying, before they devoured its flesh. This genus is quite distinct from that of the *Mullets* properly so called. Of the tropical species one of the most remarkable is the *Barracuda*, a large and voracious fish, which is nearly as much dreaded in some places as the Shark; it is, however, a very palatable article of food.

556. The next group includes a large number of Fishes nearly allied to the Perches, but having the head defended by spines and hard scaly plates. First among these we may mention the *Triglæ* or *Gurnards;* of which we have several species on our own coasts; they are known by the squared form of their heads, which are covered with bony plates. The pectoral fins are usually large; and in an allied genus, the *Dactylopterus*, or Flying Gurnard, they are of sufficient size to support the animal for a time out of the water (Fig. 250). The Gurnards emit a curious grunting or croaking noise at intervals, when taken out of the sea; and this they continue for some time. They are very tenacious of life; and mostly swim near the

bottom of the water. The swimming-bladder is usually large, and furnished with powerful muscles for its compression. To this group also belongs the genus *Cottus*, or Bull-head, which has a large and horizontally-flattened head, eyes looking upwards, and its skin almost destitute of scales, and of a dusky hue: it lurks among stones in the beds of rivulets; and its food consists of aquatic insects or small worms. The *Scorpæna*, or Hog-fish, has the head flattened sideways, and armed with spines; it is a marine fish, associating in shoals, and haunting the rocky shores. Allied to this is the *Sebastes*, or *Norway Haddock*, which inhabits the northern seas, and is an important article of food; the Greenlanders use its long spines as needles. Also belonging to this group is the *Gasterosteus*, or Stickleback, of which there are several species, some inhabiting salt water, and others fresh. The body has no proper scales, but is more or less plated at the sides; and the abdomen is covered by a sort of cuirass, formed by a union of the pelvic and humeral bones. The common name of these fish is derived from the circumstance, that instead of possessing two dorsal fins, it has only one, the anterior being replaced by a set of sharp spines varying in number; whilst the ventral fin is in the form of a sharp spine without any rays. These fishes are active and rapacious, attacking other fishes with great ferocity, and devouring almost any small animal that comes within their reach. The *Fifteen-spined Stickleback* has been seen to undergo remarkable changes in its hue, under the influence of terror.

557. We may pass over the SCIÆNIDÆ, or *Maigres*, and the SPARIDÆ, or *Sea-Breams*, to notice the SQUAMIPENNES, or *Scaly-finned* fishes; which are thus designated, from the soft, and even the spiny, portion of the dorsal fins being so covered with scales, as not to be easily distinguished from the rest of their bodies. The body, too, is usually itself much compressed, or flattened laterally. The *Chætodons*, which constitute the types of this family, are beautifully-coloured fishes of singular figure, abounding in the seas of the hotter climates. Their most common tints are black and yellow; but metallic blues and greens are not unfrequent. Sometimes the colours are disposed in spots; but

mostly in stripes or bands. They generally haunt rocky shores; and their flesh is considered excellent food. One species of this genus, the *Chætodon rostratus*, is remarkable for the manner in which it obtains its insect prey, by shooting drops of water from its long snout, so as to bring them down within its reach. Another fish of the same family, called the Archer, will in this manner shoot drops of water to the distance of three or four feet, rarely missing its aim. These fish inhabit the seas around Java; and other species are found in different parts of the Indian seas.

558. The next family, SCOMBERIDEÆ, or the *Mackerel* tribe, is one of the greatest importance to Man, from the large supply of wholesome and palatable food which it affords him. It consists of a number of species varying considerably in size; but distinguished by possessing a smooth skin, covered with a multitude of small scales; and by having a large and vigorous tail and caudal fin. They are divided into several groups, according to the form of the fins, tail, &c. In the first of these are associated the common *Mackerel*, the *Tunny*, and others, which are distinguished by having the hinder rays of the dorsal and anal fins separated into small fins. The Mackerel is remarkable for the beauty of its colours, in which it is almost pre-eminent among British fishes; and for the rapidity with which it dies and becomes tainted, when removed from the water. The periodical appearance of large shoals of this fish upon our coasts, was formerly imputed to its migration from north to south. But many facts are opposed to this idea; and there can be little doubt that it is an inhabitant of the deeper parts of the seas around our island through the whole year, and that its appearance on our coasts is solely due to its seeking the shore, for the purpose of depositing its spawn. It is during the months of May and June that this takes place; and these months, therefore, constitute the most active season for Mackerel fishing. This fish is most abundant on the southern coasts of England; but instances have been mentioned, in which large shoals have been met with even off the coast of Greenland.—The *Tunny* is

a rare fish on the shores of Britain; but it is very plentiful in the Mediterranean, and has been known and celebrated from the remotest period of antiquity, at which we have any mention of Fish by particular names. It is a far larger and stouter fish than

FIG. 267.—TUNNY.

the Mackarel, though bearing a general resemblance to it in form; a specimen which was caught when chasing Herrings into Loch Fyne, measured 7 ft. 10 in. in length, and weighed 460 lbs. The Tunnies, like the Mackarel, are dispersed through the ocean during most of the year; but in the summer they resort to the shores in vast shoals; and a fishery of great importance is then carried on along the north coast of the Mediterranean, and in the island of Sicily. The flesh of the Tunny, both fresh and salted, forms a considerable part of the food of the common people of those shores; and the fishery constitutes a large source of profit to those who reside on the coasts. The *Bonito* or *Striped Tunny*, also a native of the Mediterranean, and a rare visitant on our shores, is a very handsome fish, though smaller than the common Tunny; it is further distinguished by its great activity and voracity, being one of the chief enemies of the Flying-fish; and, in common with the Tunny, it can sustain a higher temperature than most other members of its class.

558*. Another remarkable group of this family consists of the *Sword-fish* and its allies, which have the muzzle elongated into a spike, which terminates in a sharp point, and constitutes a very formidable weapon. These fishes, of which there are several species, are usually furnished with a high dorsal fin, by the agency of which

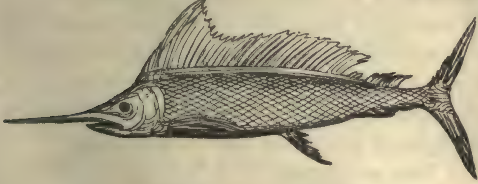


FIG. 268.—SWORD-FISH.

they are enabled to propel themselves through the water with great energy. They sometimes attain the length of 12 or even

15 feet; and they do not hesitate in attacking very large fishes (the Tunny, for example), transfixing them with their powerful spear. Instances are on record, in which even Men have been thus destroyed; and it has not unfrequently happened that a Sword-fish has struck a ship, and has driven its sharp weapon through the planking. In the Mediterranean, where one species of Sword-fish is not uncommon, it is regularly pursued by the fishermen; and its flesh is much esteemed in some places as an article of food. It is seldom seen, however, in large numbers together.—A third group of the Scomberideæ is characterised by having the rays of the first dorsal fin not connected, but existing as separate spines. Of this group we shall only stop to notice the *Pilot-fish;* which has been, from very ancient times, the subject of many fictitious statements. By the ancients it was regarded as a sacred fish, from its being supposed to indicate their true direction to doubtful voyagers; whilst, by sailors of the present day, it is commonly regarded as a guide to the Shark in its pursuit of prey, and is said to tempt it to take the bait which has been thrown out for its capture. Certain it is, however, that the Pilot-fish will often follow in the wake of ships for many hundred miles; thus an instance has been known, in which a vessel was accompanied by two of this species, during its whole voyage from Alexandria to Plymouth, which occupied 87 days. The common Pilot-fish of the Mediterranean and Atlantic does not much exceed a foot in length; but there is a species on the South American coast, which occasionally attains eight or nine times those dimensions.

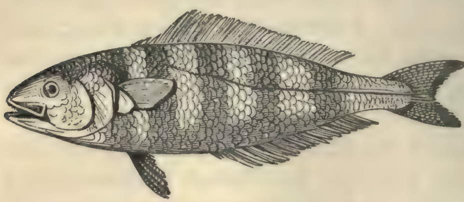


FIG. 269.—PILOT-FISH.

559. The family ZEIDÆ strongly resembles the preceding; but differs from it in the high and compressed form of the body. Many of the species composing it are remarkable for the filamentous prolongations of their fins. This is the case with one

of the types of the family, the *Zeus* or *Dory*, the peculiar form and aspect of which will be better understood from the accompanying figure, than from any technical distinction. This fish has been in great repute amongst epicures, even from the time of the Romans; it is not very common upon our own coasts, being nearly restricted to Devon and Cornwall; but it is more abundant in warmer latitudes. The name *John Dory*, by which it is commonly known in this country, is evidently a corruption of the French *jaune doré*, or gold

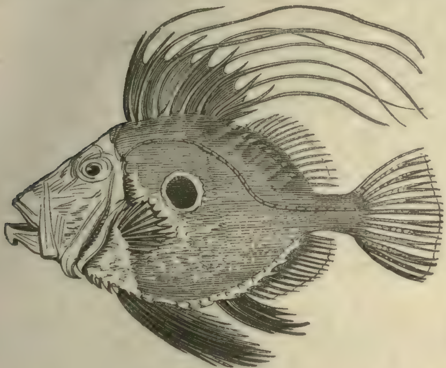


FIG. 270.—THE DORY.

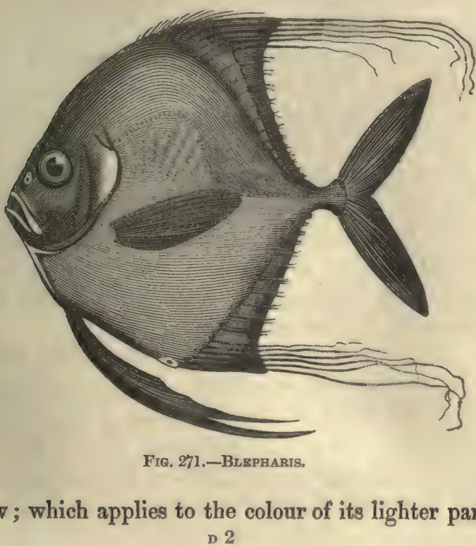


FIG. 271.—BLEPHARIS.

and yellow; which applies to the colour of its lighter parts when

the fish is alive.—Another fish of this family, no less remarkable for its form, is the *Blepharis;* of which one species, inhabiting the West Indian seas, is known under the appellation of the *Cobbler-fish*, probably on account of the long thread-like appendages for which it is so conspicuous. The use of these curious appendages is altogether unknown.—With this family may also be ranked the *Coryphæna*, or *Dolphin* of the ancients; which is a large and splendidly-coloured fish; celebrated for the velocity of its movements, and for the variety of tint which its surface exhibits under a play of light. The changes of hue which it undergoes when dying, were a source of great enjoyment to the luxurious Romans; by whose poets this Fish was much celebrated. The Dolphin of the moderns is not a Fish at all, but a Cetaceous Mammal (§ 211).

560. The two succeeding families,—TÆNIDÆ, or *Ribbon-shaped Fish,*—and THEUTIDÆ, or *Lancet-fish,*—must be passed over with but slight notice. The peculiar characters of the former are indicated by their name; the species of which it consists (some of them bearing a very close resemblance to the Scomberideæ), being distinguished by their lengthened bodies, much flattened at the sides, and having very small scales.—The *Lancet-fish* combine the small scales of the Scomberoid family with the form and small mouth of the Chætodon; but their fins are not scaly, like those of the latter. They are among the few Fishes, which live on sea-weeds and other marine vegetables. Several of the genera have sharp spines on the sides of the tail, which they can draw back into a groove; with these they can inflict severe wounds upon the hands of those who touch them incautiously; but they are peaceful in their habits, never voluntarily making an attack, but contenting themselves with repelling the assaults of their enemies.

561. The peculiar structure of the succeeding family, ANABASIDÆ, has been already mentioned (§ 538); and it adapts them to a mode of life which the circumstances of this climate do not render necessary. In cold or temperate regions, the ponds and streams, which are capable of supporting fish at all, are not dried up, except in seasons of extreme drought: but in tropical coun-

tries there are many situations, in which there is an ample supply both of food and water for Fish during the rainy season; but a complete deficiency of both, when this is succeeded by the periodical drought. Such receptacles can only be tenanted by Fish, which, like the Anabas, are furnished with the peculiar pharyngeal apparatus (Fig. 260) for keeping the gills moist; since, when one pond or stream is dried up, they can migrate in search of another. In the course of these journeys, they climb up steep banks, and even trees; and by a remarkable instinct, they seem always to travel towards the nearest water. This family contains a considerable number of genera, all of which are inhabitants of fresh-water; none have been hitherto found except in the south-east of Asia and the adjacent islands, and in Southern Africa.

562. This family is succeeded by that of Mugilidæ, or the true *Mullets;* which are distinguished by several remarkable peculiarities of structure. Their body is nearly cylindrical, and is covered with large scales; the head is broad and flat, and is covered with large angular scaly plates; and the stomach is furnished with fleshy walls, giving it a resemblance to the gizzard of a Bird. The Mullets associate in large shoals, and chiefly inhabit the mouths of rivers, where they are often seen making high leaps. They feed upon small Crabs and other Crustacea, which they swallow entire; and the almost total want of teeth is compensated by the powerful gizzard, which serves to grind down their food. The Grey Mullet is one of those fishes, which,—habitually living at the mouths of rivers, where the salt and fresh waters mix,—will thrive well in the latter alone.

563. We may next mention the Blennidæ, or *Blennies*, which are elongated Fishes, having a single dorsal fin, almost entirely supported upon simple flexible rays. The ventral fins are placed in front of the pectorals, and have only two or three rays in each. They live in small troops near the coast; and they can exist for some time without water (their gill openings being small), especially if kept in moist grass. Many of this family retain their eggs until they are hatched within the oviduct; so that the young are produced alive, fully formed, and capable of subsisting

for themselves. The *Anarrhicas*, or Sea-Wolf, must be referred to this family, although differing from it in possessing no ventral fins, and in having the jaws and palate armed with large tubercular teeth. — This fish may be almost regarded as replacing the Sharks in the Arctic seas; for it attains the length of six or seven feet, and is extremely voracious and bold. Its body, though massive, is adapted for active and energetic motion; and its powerful bite makes it a very formidable enemy. It often enters the fishermen's nets, for the purpose of plundering them of the entangled fish; and when the fishermen attack it, and it cannot dart through the net, it fights like a Lion. On the east coast of Scotland it is not an unfrequent visitor; and its appearance and habits cause it to be regarded with great dislike; nevertheless its flesh is wholesome and palatable. It is understood to prey indiscriminately upon Fishes, Crustacea, and shelled Mollusca; its jaws and teeth being capable of breaking the hardest shell. In the family GOBIDÆ, or *Gobies*, we find the same simple flexible rays in the dorsal fin, as in the preceding group; but the ventral fins are united beneath the chest, forming a sort of conical sucker, which the Fish seem to use for the purpose of occasionally attaching themselves to solid bodies. They live, like the Blen-

FIG. 272.—BLENNY.

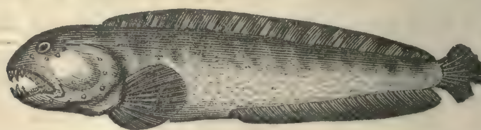


FIG. 273.—ANARRHICAS LUPUS.

nies, near the shore, and prefer a clayey bottom, in which they excavate canals, wherein they pass the winter. In spring, they prepare a sort of nest, with sea-weed; in which the young (often produced alive, as in the Blennies) are protected; and the parents exert themselves considerably to bring them food and to defend them from their enemies. Several species of Goby exist in the European seas; but none of them are of much size, or of any direct value to Man. In other seas numerous genera exist, more or less allied to the Gobies of our own coasts.

564. There are certain spiny-finned Fishes, in which the carpal bones are so elongated, as to form a sort of arm or wrist, to the extremity of which the pectoral fin is articulated. This conformation (an approach to which is seen among some of the Gobies) gives to the Fishes which possess it a very strange appearance; and enables them, in some instances, to leap up suddenly in the water, and seize the prey which they observe above them; in other cases to leap over the mud, somewhat after the manner of Frogs. From the very peculiar genus *Lophius*, or *Fishing Frog*, in which this character is combined with some others of a very extraordinary nature, the family may be designated as that of LOPHIADÆ, or *Anglers*. The common Angler of our own coasts has an enormous flattened head, which constitutes the chief bulk of the Fish; and a tail so compressed on each side, that the creature seems composed of little else than head and tail. On the former, in front of the eyes, are two long rays or filaments of a horny substance; and there are also four others of a similar nature, but shorter, on the head. The mouth also is furnished with numerous worm-like appendages; which seem to represent the tentacula or prolonged lips of many Invertebrated animals. This animal is described as concealing itself amongst marine plants, or behind hillocks of sand, rocks and stones; when it opens its great mouth and attracts small fishes as they swim past, by giving a wriggling motion to the appendages just mentioned, which causes them to mistake these for worms; so that, in attempting to seize them, they fall an easy prey to their subtle and voracious enemy, being speedily engulfed between its enormous jaws. The

hideous appearance of its monstrous and constantly-open mouth, well armed with teeth, has gained for the Angler the vulgar name of Sea Devil. There are few parts of the British shores where it is not to be occasionally met with; and when captured in nets along with other fishes, it speedily begins to swallow its companions. On some coasts it is sought for, on account of the live fish in its stomach. In the Museum of the College of Surgeons in Dublin, there is a skeleton of an Angler, about two feet and a half in length, in the stomach of which is the skeleton of a Cod, two feet long,—in whose stomach again are contained the skeletons of two Whitings of the ordinary size,—and in the stomach of each Whiting there lay, when it was first examined, numerous half-digested little fishes, which were, however, too small and broken-down to admit of preservation. The Frog-fish, with all these contents, had been taken by the fishermen, and offered for sale in the market as an article of food, without any reference at all to the size of its stomach, which was not at all unusual. The contained fishes must have been all swallowed on the morning on which the Angler was taken; as they were all, with the exception of the smallest, equally fresh and undigested.—The *Chironectes*, or Hand-fish, bears a strong resemblance to the common Angler in its structure and habits; but its fins are still more capable of motion, enabling it to walk along the ground almost in the manner of quadrupeds,—the ventral fins, however, in consequence of their advanced position, serving as the fore-legs, and the pectoral fins performing the office of hind-legs. In some of the muddy estuaries of the north coast of Australia, from which the tide ebbs far back in the dry season, these Frog-fishes are abundant, and capable of taking such vigorous leaps, that those who have visited these places have, at first sight, mistaken them for birds. Their gill openings are very small; and they can live out of the water for two or three days. They have the faculty of inflating their large stomachs with air, so as to give themselves the form of a balloon,—in this respect corresponding with the Diodon.

565. The LABRIDÆ, *Wrasse* or *Rock-fish* family, are chiefly remarkable for their thick fleshy lips; their jaws are armed with

large teeth, and their colours are for the most part very brilliant. Several species are found upon our own coasts, but they are not in much repute, and are known among the fishermen by the name of "Old Wives of the Sea." They chiefly frequent rocky shores, as their name implies.—This family also includes the remarkable genus *Scarus* or Parrot-fish; which is furnished with large convex rounded jaws, and these are covered with hard, scale-like teeth, which succeed each other from the rear to the front in such a manner, that the bases of the newest form a cutting edge. Numerous species of these fish inhabit tropical seas; many of them are remarkable for the brilliancy of their colours, whence, perhaps, their ordinary name has been derived. These Fishes appear destined to restrain the extension of the stony Corals, on the newest layers of which they are enabled, by the immense strength of their jaws and teeth, to browse without difficulty,—digesting the animal matter it contains, and setting free the carbonate of lime in a chalky state.

566. The last family of Acanthopterygii is that of FISTULARIDÆ, or *pipe-mouthed* Fishes; so named from the curious conformation of the head, which is furnished with a long tube projecting forwards, and having the mouth with its jaws at the extremity of this. There is no other point, however, in regard to which they demand peculiar notice.

ORDER II.—MALACOPTERYGII ABDOMINALES.

567. The CYPRINIDÆ, or *Carp* tribe, constitute the first family of this order; they are characterised by their small mouth, and by their feeble and generally toothless jaws; but they have the pharynx strongly toothed, which compensates in some degree for the feeble armature of the jaws. They are for the most part fresh-water fishes, and live on aquatic plants. These are masticated in the pharynx, which is a powerful instrument of reduction, being furnished with strong muscles, that bruise the food between its teeth and a stony disc fixed at the base of the skull. The common *Carp* was not originally a native of

this country, but was introduced from the South of Europe; it thrives very well, however, in the most slow-running parts of rivers, and still better in ponds, sometimes attaining the length of four feet. The beautiful little *Gold* and *Silver Fish*, belong to a small species of Carp, which is very much disposed to pass into varieties. Nearly allied to these are the *Barbel*, which sometimes attains the length of ten feet; it inhabits ponds and sluggish streams; and is said to plough up the mud with its long snout, so as to set adrift in the water the minute animals imbedded in it, and thus to attract the small fishes on which it is itself supported.

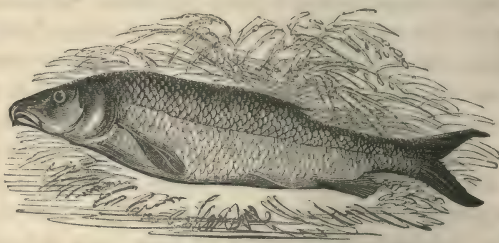


FIG. 274.—BARBEL.

The *Gudgeon*, *Tench*, *Bream*, *Roach*, *Bleak*, *Minnow*, and many other well-known pond and river-fishes, belong to this family; as do also the *Loach*, which habitually buries itself in mud when the weather is cold; and the *Anableps*, which is remarkable for being apparently possessed of four eyes. This is not, however, really the case; for although the cornea and iris are divided by transverse bands, so that there are two *pupils* on each side (ANIM. PHYSIOL. § 533), yet the other parts of the eye are single. The female of this species brings forth her young alive, in a state of considerable advancement.

568. The family ESOCIDÆ, or *Pike* tribe, is nearly allied to the preceding; but differs in having the jaws and palate usually beset with teeth, and in the voracity of the fishes which it includes. Many of these are inhabitants of fresh waters; others occasionally ascend rivers; whilst others again are confined to the sea. The common *Pike* is well known as being one of the most voracious

FIG. 275.—PIKE.

and destructive of all the smaller fishes. Mr. Jesse mentions, that eight Pike, of about 5 lbs. weight each, consumed nearly eight hundred Gudgeons in three weeks; and that one of these devoured five Roach, each about four inches in length, within a quarter of an hour. The Pike not only makes havoc among other fish, but will devour frogs, water-rats, field-mice, and the smaller aquatic birds; and instances are on record, in which it has even attacked Man. It grows rapidly, and sometimes attains the weight of more than 30 lbs. It is a very long-lived fish,—having been known to attain the age of 90 years,—and having in one instance (there is reason to believe) lived to the patriarchal age of 267 years, and attained the length of nineteen feet.—The *Gar-fish*, or *Sea-Pike*, has a much more elongated mouth, which is not so well furnished with teeth. It is quick and active in the water; swimming with considerable rapidity near the surface, and leaping and gambolling as if in the exuberance of vivacity. This fish comes in shoals to the southern coast of Britain, in the months of April and May; and from its appearing a short time before the Mackarel, it is termed by the fishermen the Mackarel-guide. It is not in much esteem as an article of food.—To this group also belongs the *Exocetus*, best known as the *Flying-fish;* which is remarkable for the enormous development of its pectoral fins, and for its power of sustaining itself upon them out of water. It is necessary to bear in mind that the term *Flying-fish* has been applied to this genus, in common with the *Flying Gurnard* (§ 555); and that, although really so different, they have been continually confounded together in the accounts of voyagers. The term Flying-fish ought to be restricted to the Exocetus; which is the one that best deserves it. Various species exist in different parts of the seas of warm latitudes; and our own coast has been occasionally visited by them. As elsewhere stated (ANIM. PHYSIOL. § 667), their flight through the air seems entirely to depend upon the impulse they receive from the stroke of their fins upon the water, at the moment of quitting it. They are to a certain degree *supported* by their wing-like fins, while sailing through the air; but they do not seem able to raise or to propel them-

selves by striking them against it. The most usual height of their flight is from two to three feet; but they have occasionally been known to spring to a height of fifteen or even twenty feet. The utmost length of their flight seems to be between two and three hundred feet; and its extreme duration about thirty seconds. Few spectacles are more beautiful, than the sudden rise of a shoal of Flying-fish from the gently-undulating surface of the tropical ocean,—their scaly surface and extended fins glistening in the bright sunshine with all the varied hues of the rainbow,—and the graceful curves in which they move at last terminated by a return to their native element, from which they presently again spring up with renewed vigour. These airy excursions are commonly regarded as occasioned by the pursuit of Dorados, Bonitos, and other fishes of prey; but this is probably by no means the case, for the Flying-fish seem frequently to rise from the water for the mere sake of exercising, with pleasure to themselves, those powers of movement with which they are endowed,—just as we see other fishes gambolling about in their usual medium. Whilst in the air, they are often seized upon by the long-winged sea-birds.

569. The next family, SILURIDÆ, or *Silure* tribe, is distintinguished by the want of scales, having only a naked skin, in which large bony plates are frequently imbedded. Many of them have the adipose or fatty second dorsal fin, which is a prominent character of the next family. The species included in this group are mostly river-fish, of considerable size, inhabiting warm climates. Many of them have the first ray of the pectoral fin very strong and bony; and the fish can, at pleasure, lay it flat on the body, or keep it fixed in a perpendicular direction, in which case it becomes a formidable weapon, capable of inflicting very troublesome wounds. There is no sufficient reason, however, to believe that these wounds are venomous.—The *Malapterurus*, remarkable for its electrical powers, has been already noticed (§ 543).

570. The two remaining groups of this order are of great importance to Man, from the large supply of wholesome and palatable food which they yield. The first of these is the family SALMONIDÆ, or *Salmon* and *Trout* tribe; which is characterised

by having all the rays of the first dorsal fin soft or jointed; and the second dorsal entirely adipose, being merely a fold of skin inclosing fat. The species of this family are at once distinguished from the Siluridæ, by having the body covered with scales; they are generally very muscular, and possessed of great strength; and they are voracious in their habits, feeding rather upon Insects, small Crustacea, &c., than upon other Fishes. The different subdivisions of the group vary considerably in regard to the position of the fins, and the degree in which the mouth is armed with teeth. Most of them frequent the estuaries of rivers, and ascend the stream at regular periods to deposit their spawn in its higher parts; and it has been ascertained that the same fish and their descendants resort in successive years to one particular locality. Nearly all the members of the family are clouded with transverse dusky patches when very young, and undergo considerable changes in their livery before they arrive at their full growth. Hence there is much difficulty in determining their species; which is increased by the circumstance, that the male, in many instances, appears to be capable of propagation long before arriving at its full growth. The *Salmon* of our own rivers is one of the largest of the whole family; but in consequence of the eagerness with which it is pursued by fishermen, it does not often attain its full size in this country. Enormous specimens, however, are now and then captured; a weight of 40 lbs. does not seem very uncommon; and in 1821, a specimen was exhibited in London, weighing 83 lbs. The usual time at which the Salmon leaves the sea, is the autumn; it remains in the rivers during the winter; and returns to the sea, after having deposited the spawn, in the spring. The young fry, termed Smalts, are carried down to the sea in the months of April and May. In some rivers, however, they do not make their ascent until the winter; and in others they even delay it until the spring. These variations appear to depend upon differences of temperature in the rivers themselves; since, when these are very cold, the fish avoid passing the winter in them. Before depositing its spawn, the Salmon makes a furrow with its nose in the gravelly bed of the river; and its eggs, when

deposited in this, are carefully covered up. The common *Trout* is entirely a fresh-water fish, delighting in rivers which have a rapid current, and abounding also in many stream-fed lakes; it lurks during the day in the deep pools, under the shadow of large stones, or under precipitous banks; and becomes active towards evening, when it begins eagerly to pursue its prey, which seems to consist especially of Insects and aquatic Larvæ, and of small Crustacea,—but also of small fishes, and the ova of the larger ones.—The *Char* is considered as having the most delicate flavour of any of the fishes of this family; it is a lake fish, and is not very common in this country.—The *Smelt* resembles the Salmon in its habits, but is much smaller; it has been found, however, to thrive very well when confined to fresh water.—Several other genera exist in various parts of the world; some of them approach other families in their general structure, and are exclusively marine in their habits.

571. The only remaining family of this order is that of CLUPEIDÆ, or *Herrings*, and their allies. These have a scaly body like the Salmon's, but no adipose dorsal fin; and there is also a difference in the arrangement of the bones of the jaws. They are for the most part marine fishes; only a few species, as the Shad and White Bait, ascending rivers periodically like the Salmon. The habits of the common *Herring*, in regard to its reputed migrations, have been already noticed (§ 546); notwithstanding the very circumstantial account given by Pennant, and copied by later authors, it seems now to be well established that the only migration of the Herring is from the deep seas to the shores at the spawning season, and from the shores to the deep seas when this is over. It is a curious and perplexing circumstance, that the shoals of Herrings do not continue to resort to the same localities; but that they will leave some parts of the coast which they had been accustomed to visit with regularity, and will make their appearance on others which they had not previously frequented. Their food consists of small Crustacea and Fishes; and it appears that they do not spare the young of their own race, five small herrings having been found in the stomach of a large female. They usually swim near the surface of the water;

and, like other fishes whose habit is the same, their gill-openings are large, their respiration considerable in amount, their muscular energy great, and their demand for oxygen so constant, that, when taken out of the water, they speedily die. The *Pilchard*, *Sprat*, *Shad*, *White-Bait*, *Sardine*, and *Anchovy*, are all more or less closely allied to the Herring,—the last departing from it most widely. The range of the Pilchard, which abounds on the Cornish coast, is more southern than that of the Herring; and the Anchovy and Sardine replace the Herring in the Mediterranean, where it is unknown. The importance of the Herring and Pilchard Fisheries is very great.

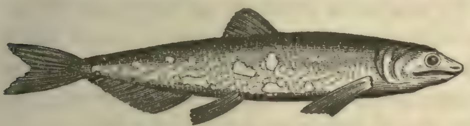


FIG. 276.—ANCHOVY.

Some notion of it may be formed from the fact, that nearly 500,000 barrels of herrings only have been cured in one year; of which more than half were exported. The number of persons to whom this Fishery gives employment in various ways, must, therefore, be very considerable, though it cannot be exactly estimated; and the value of the product as an article of export trade is very important. The total number of persons *directly* employed in the Cod and Herring fisheries of Britain, as Fishermen, Coopers, Curers, &c., was nearly 87,000 in the year 1836. Of the extent of the Pilchard fishery some idea may be formed from the fact, that about 12,000,000 of these fish have been sold for home consumption alone in a single year; and it is said that more than this number have been brought into one port in a single day. The principal centre of the Herring fishery is at Yarmouth in Norfolk; that of the Pilchard fishery is the neighbourhood of the Land's End.

572. With the preceding order is arranged by Cuvier the *Lepidosteus* or *Bony Pike*, which has many of the characters of the Pike, with the structure of the head of the Herring. It differs from both these, however, in having the body covered with a case composed of dense bony square scales; which are so fitted together as to form a most complete armour. An in-

creased knowledge of its internal structure, however, and of the fossil species most nearly allied to it (which are very numerous in the older rocks), has led to a very different position being assigned to it. Its skeleton differs in many particulars from that of ordinary Fishes, and presents several points of resemblance to Reptiles; and this approximation is equally remarkable in the structure of the respiratory apparatus,—the air-bladder being double, and communicating with the œsophagus by a regular trachea or wind-pipe, furnished with a glottis at its upper extremity, so as to be nearly as complete as the lungs of the Siren. In regard to the order of *Sauroid* fishes, of which this is nearly the only genus at present remaining, but which was once the predominant group of Fishes, more will be said hereafter (§ 582). The Lepidosteus is an inhabitant of the rivers and lakes of America, most of the species being restricted to its warmer parts.

Order III.—MALACOPTERYGII SUB-BRACHIATI.

573. The Fishes of this order, from the position of their fins, have greater facility of ascending and descending, than the abdominal fishes; and the range of depth inhabited by the same animal is consequently greater,—except where, as in the Flat-fish, there is a peculiar adaptation to a residence at the bottom of the sea. The first family is that of the Gadidæ, or the *Cod* tribe; which have a long body, rather slender, and covered with soft scales,—the head, however, being naked. They live for the most part in the seas of cold or temperate climates; and from their size and their tendency to congregate in particular localities, as well as from the wholesomeness and good flavour of their flesh, they are probably more important to Man than any other family of Fish. The Cod fishery on the banks of Newfoundland sends a vast supply to almost every part of the world; and the amount caught on the British shores also is very considerable. The appearance and quality of the fish vary considerably according to the nature of the ground on which it is taken. Its repro-

ductive powers are enormous; the roe of a single female having been estimated to contain nine millions of eggs. Nearly allied to the Cod, are the *Haddock*, *Whiting*, *Hake*, *Ling*, *Rockling*, *Coal-fish*, and others. The first of these is considered as the most delicate of the whole family, when fresh; but it does not take salt well; and for preservation, the Cod and Ling excel the rest.

574. The second family of this order consists of the PLEURONECTIDÆ, or *Flat-fish*. These present several remarkable peculiarities of structure; by which they are distinguished, not only from all other Fishes, but even from all other Vertebrated animals. Their body is extremely compressed, or flattened at the *sides;* the animal, however, does not habitually swim with these sides erect in the water, but usually lies flat on the bottom, one side being in contact with it, and the other being directed upwards. The lower side is generally white, whilst the upper is brown; and the former is commonly (but erroneously) regarded as the belly of the fish, and the latter as its back. The dark colour of the upper surface harmonises with that of the bed on which the fish lie; so as to enable them to conceal themselves from their foes, or to watch for their prey, without being themselves observed. Individuals are occasionally met with, in which both sides are coloured alike; these are said to be "Doubles." It is usually the coloured side which is doubled; though it is occasionally the white one. By a change in the position of the head, both the eyes are brought round to the light side, so as to look upwards, when the fish is lying on the bottom; this change may be designated as a sort of twisting-round; but it also involves an unequal development of the bones on the two sides of the head, which shows itself in the mouth. Of the pectoral fins, too, one is usually larger than the other. The dorsal fin is continued along the whole of the ridge of the back, from the head to the tail; and the anal fin usually forms a like continuous expansion below, sometimes uniting with the ventral fins. These fishes have no air-bladder, and they seem to have little power of rising from the bottom. When disturbed, they will raise themselves into a vertical position, so as to show their white sides; and

they then dart along with great rapidity; but they soon return to their usual posture, and glide along with a sort of undulating motion, at a little distance from the bottom. The Flat-fishes are very tenacious of life; and the flesh of all of them is very palatable. That of the Turbot is considered as the most delicate afforded by any marine fish. Although most of the species are exclusively marine, yet the Flounder and some others occasionally ascend rivers, and thrive in brackish, or even in quite fresh water. The *Plaice*, *Flounder*, *Turbot*, *Dab*, *Fluke*, *Brill*, *Sole*, and other well known fish of this family, are closely allied to each other, both in structure and habits; and they are all inhabitants of British seas. The *Halibut*, also an inhabitant of the Northern seas, is larger than any one of these, attaining a length of six or seven feet, and a weight of 300 or 400 lbs. Its flesh is rather coarse and dry, but it admits of being salted. In some of the Mediterranean species, the eyes look towards the left side, instead of towards the right; the latter, though the ordinary rule of the family, is sometimes departed from in other species; the individuals that exhibit the unusual formation, being said to be "reversed." As an instance of the extent and importance of the Fisheries, of which this family is the object, it may be mentioned that the Dutch draw about 80,000*l.* per annum, for the supply of Turbot alone to the London market; and it is estimated that, of the whole quantity brought to Billingsgate, the Dutch is not more than one-fourth.

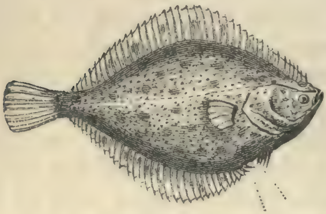


FIG. 277.—PLAICE.

575. The third and last family of the second division of Soft-rayed fishes, is but a small one; and consists of a group which is characterised by the union of the ventral fins into a sort of sucker, or disc, that enables them to form a strong adhesion to rocks and other hard substances. In this manner they can remain and find their food, in situations where every other

species of fish would be swept away by the current. From this curious conformation, they have received the name of DISCOBOLI. Their skin is slimy and naked, or with hard grains imbedded in it. Their pectoral fins are large; and they swim with great vivacity in shallow water, and near coasts. Several species of this family, most of them small, are found on the south and west coasts of England. One of the largest is known as the *Lump-fish;* this is found as far northwards as the margin of the Polar ice, and is a palatable article of food; its name is derived from the clumsiness of its form, its height being about half its length, and its thickness about half its height. The *Remora*, or *Sucking-fish*, (§ 529), is placed by Cuvier in this family, although its disc, or sucker, is so entirely different in its position; but he remarks, that it might be placed by itself, as the type of a distinct family.

ORDER IV.—MALACOPTERYGII APODA.

576. The fishes in which the ventral fins are always wanting, form but a single natural family; MURÆNIDÆ, or the *Eel* tribe. These are at once known by their long, slender, snake-like bodies, covered with a soft skin, and having the scales very minute, and often almost invisible. The gill-orifices are very small, and are prolonged far back, so that a sort of long passage is formed from the branchial chamber to the surface of the body. In this manner the gills are so much sheltered, that the fish can remain out of the water for a considerable time, without those organs being rendered unfit (by becoming dry), to carry on the respiration. Of course, the access of water to the gills cannot at any time be so free, as it is in fishes with large gill-openings; and their respiration may be habitually less. It is in animals with a feeble respiration, as has been already remarked in the case of Reptiles, that we find the greatest tenacity of life; and every one knows the difficulty with which the Eel is killed—the most cruel injuries being sustained by it without the loss of its vitality. The ordinary Eels, of which there are several species,

inhabit ponds, rivers, and the brackish water at the mouths of rivers. In the autumn they make their way to the sea in vast numbers; for the purpose, it is believed, of depositing their spawn. Myriads of minute Eels, three or four inches long, are seen in the spring, making their way up rivers, and dispersing into the tributary streams as they proceed; but whether the parent Eels thus return is uncertain. It is well known that the Eels which inhabit inland lakes and ponds, whence they cannot escape to the sea, are able to breed without this migration; but it appears that their season is somewhat later, the water in such situations being colder than that of the sea in the early spring. Eels frequently quit the water, in warm, damp nights, and wander over the grass; either in quest of worms, frogs, or other food; or in order to change their locality.—Many of this family are chiefly marine; though they occasionally stray into the mouths of rivers: this is the case, for instance, with the *Conger*, which is one of the largest of the whole order, sometimes measuring six feet in length, and being as thick as a man's leg.—The *Ophisurus*, or *Snake Eel* (so called from its strong resemblance to a serpent) of the Mediterranean, attains the same length, but is not so thick. In the genus *Murœna,* and its allies, the pectoral as well as the ventral fins are wanting; and the gill-openings are extremely small. This, too, is a Mediterranean fish; it was much esteemed by the ancients, who kept it carefully in ponds; and there is a well-known story of a cruel master, who caused his offending slaves to be flung alive into the ponds, to feed the Muræmæ. The common species grows to the length of three feet or more; its surface is mottled brown and yellow; and it is very voracious and ugly. In some of the genera nearly allied to this, the gill-passages unite, so as to open externally by a single orifice on the under side of the neck; and in several of these, we find the air-bladder almost as completely presenting the characters of a rudimentary lung, as in the Sauroid Fishes (§ 588).

577. The *Gymnoti*, or *Electric Eels* (§ 540), and their allies, have been separated from the preceding family by some naturalists, on account of the less complete inclosure of the gill-covers

by the skin, and of the absence of the dorsal fin (Fig. 262). It is to the true Gymnotus, that the electric power is confined; and the group includes several other genera, of which some belong to the British seas. Of these may be mentioned the *Leptocephalus*, or *Morris*, which is a small riband-shaped fish, with a body so thin and transparent that its internal structure can be seen without dissection; it lurks among sea-weeds, and is very lively in its motions. The *Amnodytes*, or *Launces*,—one of which is known to fishermen by the name of the Sand-Eel, and another as the Sand-Launce,—are remarkable for their habit of burrowing in the sand, in which they find the worms that constitute their chief food. They become in their turn the prey of the Salmon; to whose support, whilst they are in the estuaries of rivers, the Launces are believed to contribute largely.

Order V.—LOPHOBRANCHII.

578. This order consists of a small group, which is separated from all other Osseous Fishes by the structure of the gills; which, instead of hanging from the branchial arches in fringes of parallel fibres, disposed like the teeth of a comb, are set upon them in small round tufts, arranged in pairs. From this peculiar conformation, the name of the order, which signifies *tuft-gilled*, is derived. The gills are defended by a large operculum, which is attached by a membranous covering on all sides, except at one part where a small hole is left for the escape of the water. These fishes are also distinguished by having their body covered with shields or small plates, which often give it an angular form. In general they are of small size, and often without flesh. They do not present many points of general interest; but there are certain peculiarities in their organisation, which are very interesting to the Naturalist. In the *Syngnathus*, or *Pipe-fish*, which has a prolonged muzzle like that of the Fistularidæ (§ 566), the eggs are not deposited as in other Fishes, but are conveyed into a sort of pouch, formed by a doubling of the skin under the body of the male; this pouch is under the abdomen in some

species, and at the base of the tail in others. In this pouch the eggs become matured; and when the fry are ready to escape, it opens and allows them to pass out. This contrivance reminds us of the pouch of the Marsupial Mammalia; but there is this striking difference, that in the latter it is the Female which affords this protection to the young, whilst in the Pipe-fishes it is the Male. It has been asserted that, even after the young have quitted the pouch, they will return to it again; and that the parent shows great attachment to them. The *Hippocampus* (Fig. 259) has a prehensile tail, unfurnished with any finny expansion; and is enabled by its means to climb or hold on by the stalks of marine plants. It is only in the dead specimen, that the neck acquires the peculiar bend, which gives its head the resemblance to that of a Horse, from which its name is derived. The *Pegasus*, though furnished with a snout, has the mouth beneath it; the pectoral fins are large, and are spread out in a wing-like manner; whence these curious Fishes have derived their name, which signifies Flying Horses.

Order VI.—PLECTOGNATHI.

579. We next come to another small order, which forms a connecting link between the Osseous and Cartilaginous fishes. It resembles the latter, in having the upper jaw attached to the cranium, in such a manner as to possess but little power of motion (whence is derived the name of the Order, which means having the jaws soldered), and also in the imperfect ossification of the skeleton. Still, in its general conformation, the skeleton rather resembles that of the bony fishes. The gill-lid is concealed under the thick skin, as in the preceding Orders; and there is but a small gill-opening on either side: the ribs are scarcely developed. This Order includes two families, which are distinguished by the structure of their teeth. In the first of these, the *Gymnodontes*, or Fishes with naked teeth, the jaws are shaped like the beak of a Parrot; and are composed of parallel plates of a substance resembling ivory. These are reproduced as

fast as they are destroyed by wear; and they constitute very efficient instruments for grinding down the food on which these animals live,—which consists of Crustacea and sea-weeds. To this family belong the *Globe-fishes;* which are so named from their power of distending themselves into a spherical form, by inflating with air a large sac contained in the abdomen. When thus distended, they float along the water with the back downwards, swimming onwards by means of their pectoral fins; and they are covered with a series of large spines, which are raised up when the body is thus inflated, so as to form a very efficient means of defence. From this last circumstance, these Fishes have been sometimes termed Porcupine-fish. There are three genera in which this curious power exists; the *Diodon* (two-toothed), in which there is no furrow or division in the jaws, so that each seems like a single tooth;—the *Triodon* (three-toothed), in which there is a division in the centre of the upper jaw; so as to divide it, as it were, into two teeth;—and the *Tetrodon* (four-toothed), in which there is a division of this kind in each jaw. Besides these, this family contains the *Orthagoriscus*, or *Sun-fish* (so named from its rounded form), which looks like the anterior half of a fish cut in two in the middle. It has the power of floating with its head and eyes above water; but not of distending itself with air; in this state it moves along sideways, very slowly, however; and appears like a dead or dying fish. The Sun-fish (or Moon-fish, as it is sometimes called) attains a considerable size; of the short species, which is most remarkable for its peculiarity of form, individuals have been frequently caught measuring four feet in length, and nearly as much in breadth, and weighing 400 lbs.; and it has been stated occasionally to attain double that weight.

580. In the second family, that of BALISTIDÆ, or *File-fishes*, the jaws are armed with a small number of distinct teeth; the skin is either rough, or covered with very hard scales,—whence their name, and the mouth is prolonged into a sort of pyramid. In their general form, and in the brilliancy of their colours, they bear a considerable resemblance to the Chætodons (§ 556); and, like them, they inhabit the seas of warm regions, keeping near

the surface, or in the neighbourhood of rocks. Some of them are remarkable for the appendages with which the body is furnished, which are especially striking in the *Balistes pencilligerus;* their use, however, is entirely unknown.—The *Ostracions, or Trunk-fishes,* should probably be placed in a distinct family, so remarkably are they distinguished by the mode in whch the body is protected.

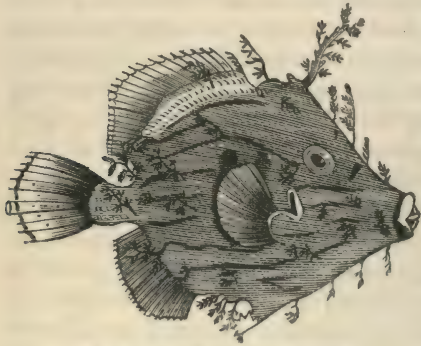


FIG. 278.—BALISTES PENCILLIGERUS.

The head and body are covered with plates of bone, soldered together in such a manner as to form an inflexible cuirass; leaving only the tail, the fins, the mouth, and a small margin of the gill-opening, capable of motion,—all of which moveable parts pass through openings of the cuirass. The greater part of the vertebræ also are soldered together. There are no ventral fins, and the dorsal and anal are small and are placed far back; there is little flesh; but the liver is large, and abounds in oil. The surface is often armed with spines. No species of these singular Fish are known in the British seas.

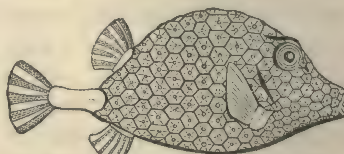


FIG. 279.—TRUNK-FISH.

Order VII.—CHONDROPTERYGII BRANCHIIS LIBERIS.

581. We are now arrived at the true Cartilaginous fishes (§ 525); of which the first order so far resembles the Osseous group, that the gills are connected externally with a single wide opening on each side, furnished with an operculum, or gill-cover. All the Fishes of this order are considered by Cuvier as belonging to a single family; but they may be probably better arranged under two families, the Acipenseridæ, or *Sturgeons*, and the Chimæridæ, or *Chimæras*,—the former having more affinity to the Osseous fishes, and the latter to the Sharks. The body of the *Sturgeon* is more or less covered with bony plates,

Fig. 280.—Sturgeon.

arranged in longitudinal rows; and the head is armed with the same. The mouth is situated beneath the elongated muzzle, and is small and toothless. The air-bladder is very large, and communicates by a wide opening with the gullet; and in this, and other points of their internal conformation, the Sturgeons show a considerable approach to the Lizards, whence they are ranked among the *Sauroid* fishes (§ 588). The form of the tail is another mark of resemblance; for the vertebral column is continued into the upper portion of the caudal fin, the lower one being given off from its underside,—instead of stopping short at its commencement, and sending off the upper and lower portions of the fin in the same manner, as in nearly all other Fishes (Fig. 246). Sturgeons, like Salmon, ascend large rivers for the purpose of spawning; and they are the subject of valuable fisheries. They are more abundant in the Continental rivers than in those of Britain; and are particularly numerous in those

which fall into the Black and Caspian seas. The common Sturgeon attains the length of six feet; but the great Sturgeon has been found twelve or even fifteen feet in length, and weighing from 1200 to 3000 lbs. The flesh of the former is very palatable and wholesome, resembling veal in its character; that of the latter, however, is not esteemed. The *Sterlet* is a smaller species, about two feet long; which is found in the Russian rivers, and is considered a great delicacy. All the species are valued on account of the excellent Isinglass which is yielded by their air-bladders; and their roe is salted and prepared by the Russians, forming a dish termed *caviare*. More than 400,000 lbs. of this have been prepared in the Caspian fishery, in a single year.—The CHIMÆRIDÆ have the gills not entirely free at their extremities, but partly attached, as in the Sharks; and although there is externally but a single gill-opening, yet internally there are five separate passages, terminating in the common aperture. They lay large, flattened, eggs, included in a sort of leathery covering; in which respect, also, they resemble the Sharks. The commonest species is known under the name of the "King of the Herrings."

ORDER VIII.—CHONDROPTERYGII BRANCHIIS FIXIS.

582. This order includes the two families of Sharks and Rays; which, though very different in external form, agree in many points of internal structure, and particularly in having the gills fixed at their extremities to the outer sides of the gill-cavity, and in having a series of apertures, through which the water passes out from each branchial arch. In these particulars they correspond with the last order of the class,—that of Cyclostome Fishes; but they differ from them in having a much more perfect skeleton, and in having both pectoral and ventral fins. The differences between the two families of SQUALIDÆ, or the *Shark* tribe, and RAIDÆ, or the *Ray* tribe, chiefly consist in their external form; the body in the former being elongated, and the

tail extremely fleshy; whilst in the latter the body is short and flat, the pectoral fins immensely extended, and the tail slender. Of the true *Sharks*, there are several species, of which the *White-*

FIG. 281.—WHITE SHARK.

shark is the most notorious. It sometimes attains the length of twenty feet, and its mouth is sufficiently wide to enable it to receive the thigh or even the body of a Man. This species inhabits most of the seas of warm latitudes; but it is rarely or never seen near our own shores. The *Fox-shark*, or *Thresher*, is

FIG. 282.—FOX-SHARK.

remarkable for the great development of the upper lobe of the caudal fin, into which the vertebral column is prolonged (§ 581); this being nearly as long as the entire body. This fish is occasionally met with on our own coasts, and sometimes attains the entire

length of from ten to twelve feet. Its gape is not so wide, nor are its teeth so formidable in proportion to its size, as those of the preceding; but its tail is a powerful weapon, and it is exceedingly bold and voracious in its disposition. It has been stated on good authority, that it is not uncommon for a Thresher to approach a herd of Dolphins which may be sporting in unsuspicious security, and by one splash of its tail to put them all to flight, like so many hares before a hound; yet the Dolphin is six times the bulk of the Thresher.—The *Blue-shark* bears more resemblance to the White in its general form, but is much smaller, not exceeding six or seven feet in length. It is very common off the Cornish coast, and is extremely troublesome to the fishermen during the Pilchard-fishing season, cutting their lines and nets, and devouring the fish.—The *Porbeagle* belongs to an allied genus, *Lamna*, which differs from the true Sharks in having a pyramidal snout, and the gill-openings placed rather further forwards. Its common name seems to be compounded of Porpoise and Beagle; for it bears some resemblance to the former in shape, whilst it corresponds with the latter in its habit of hunting in packs. It is occasionally met with on almost all parts of the British coasts, being found chiefly in currents near rocky places; it is voracious in its habits, swallowing entire Fishes of two feet in length.—The *Notidamus*, which is an inhabitant of the Mediterranean, is the largest of the true Fishes, its length being sometimes as much as thirty-six feet; but it is comparatively harmless.

583. This family contains many other genera, more or less departing from the ordinary type; among these we may mention the curious *Zygæna* or *Hammer-headed Shark;* which resembles the ordinary Sharks in the form of its body, but has its snout prolonged into the form of a double-headed hammer, with an eye in the middle of each extremity. It is occasionally met with in European seas, attaining the length of twelve feet, and larger ones are said to inhabit the tropical ocean.—The *Dog-fish* is nearly allied to the Sharks; and is probably more abundant on our own coast than any other of the order. Almost every one who walks along the shore may meet with its

eggs, which are enclosed in flat oblong cases, with a long tendril from each corner, by which it clings to solid bodies, or to sea-weed. In these cases, which are commonly known by the name

283.—HAMMER-HEADED SHARK.

of "fairies' purses," there is a fissure at each end, which admits the free access of sea-water to the egg; and through one of these the young subsequently escapes. The Small Spotted Dog-fish is the species most common on our own shores; and it is not only very troublesome to the fishermen by entangling itself in their nets, but also by frightening away the shoals of Herrings, &c., which are migrating towards the coast.—The last fish of this family here to be noticed, is the *Pristis* or *Saw-fish;* so named

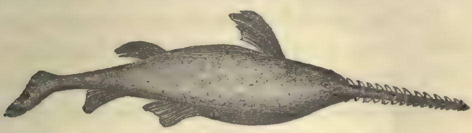


FIG. 284.—SAW-FISH.

from the extension of its snout into a long flat blade, furnished with a row of sharp spines, resembling teeth, on either side. With this formidable weapon the Saw-fish attacks the largest Whales, and inflicts very severe wounds. It sometimes attains

the length of twelve or even fifteen feet. This fish is very widely distributed, being found in the arctic, antarctic, and tropical seas; but it seldom approaches the shore.

584. The true *Rays*, typical of the family Raidæ, have the body so flattened, that the pectoral fins seem like a continuation of it; and these meet in front of the snout, and are prolonged backwards as far as the ventral fins; thus giving to the whole body a nearly circular form. The eyes are situated on the upper side of the body, as in the Flat-fish (§ 564); but it will be observed, that the plan of construction of the Rays and Skates, is entirely different from theirs, the two margins being here composed of the edges of the pectoral fins, whilst in the Flat-fish they are formed by the dorsal and anal; and the Flat-fish habitually lying on one side, whilst the Rays, &c., lie on the abdominal surface, where we find their mouth and gill-openings. These fish live for the most part near the bottom of the water, on beds of sand or mud. When disturbed, they glide along in an undulating manner, with a slight motion of the pectoral fins; and if attacked, they defend themselves by lashing violently with the tail, which is often furnished with sharp spines. In the *Sting-Ray* (*Trygon*), the tail has a single strong spine, notched on both sides. There are several species, intermediate in form between the Sharks and Rays, by which the two families are connected. Most of the family are extremely voracious, feeding on Fishes and Crustacea, and on naked or testaceous Mollusks. The teeth are flattened and lozenge-shaped; and so powerful are the jaws, that they are capable of crushing the shell of a Crab with the greatest ease. Some of the Rays produce their young alive; in those which lay eggs, these are deposited in a horny case, like that of the Dog-fish. One of the most common of the British species is the *Thornback;* so named from the skin of its back being covered with thorny tubercles, variable in their number; this fish is taken in abundance in the spring and summer, when it visits the shallows for the deposition of its

Fig. 285.—Sting-Ray.

eggs, and it is an excellent article of food. The *Torpedo*, or *Electric Ray* (§ 542), is occasionally met with on the Channel-coast of England ; but it is more common in warmer seas, especially the Mediterranean. It is peculiar, not only from the possession of the electric apparatus, but also on account of the fiddle-shaped form of its body (Fig. 263). The *Myliobates* receives its common name of *Sea-eagle*, from having the pectoral fins of extreme breadth, so that it much resembles a bird of prey, with its wings expanded. It inhabits the depths of the ocean, and attains a very large size ; in a specimen caught in the West Indian seas, the length of the body was 10 feet, its greatest breadth 13 feet, and the length of the tail 15 feet.

ORDER IX.—CYCLOSTOMATA.

585. The Fishes of this Order are the least perfect of the whole class, in regard to the construction of their skeleton ; and are, therefore, at the bottom of the whole series of Vertebrated animals ; which they may be correctly regarded as connecting with the Invertebrated sub-kingdoms. So far are they from having a jointed vertebral column, that this is replaced, in the highest among them, by a sort of cylinder of cartilage, which represents the bodies of the vertebræ, but which does not show any definite division into segments ; and in the lowest, this cylinder has not even the firmness of cartilage, but consists of a membranous bag, containing a gelatinous semi-fluid substance. There are no ribs, nor are there either pectoral or ventral fins ; there is, in some, however, a kind of fin beneath the tail, but this has no rays. The body is usually prolonged, and nearly cylindrical ; and terminated by a circular mouth adapted for sucking. In the *Lampreys* there are seven gill-openings on each side ; there are strong teeth in the ring formed by the pair of jaws ; and the inner part of the disc, which may be considered as the lip, is also beset with hard tooth-like tubercles. The tongue, which moves backwards and forwards like a piston, and which is the principal instrument in the act of suction, is also furnished

with two longitudinal rows of small teeth. By means of this sucker, the Lamprey can attach itself to the bodies of the largest

FIG. 286.—LAMPREY.

fishes; and is able speedily to pierce through their integuments, and to prey upon their substance. The largest species, which attain the length of two or three feet, are marine; the former, which chiefly inhabit rivers, are sometimes called Lamperns. The members of the genus *Myxine*, or *Hag*, and its allies, have not even a cartilaginous ring around the mouth, its borders being entirely membranous, and furnished with only one tooth. The mouth is surrounded by eight cirrhi, or tendril-like feelers; which remind us of the arms of the Cuttle-fish in miniature. This fish is destitute of eyes; and does not seem, indeed, to have any other special organ of sensation than these cirrhi. The best known species is known to British fishermen under the name of the *Hag;* it is found in the interior of other fishes, whose bodies it has entered for the purpose of devouring them; and it seems to attack in preference those which have been hooked, and which, consequently, are not able to defend themselves. As many as six Hags have been found in the skin of a single Haddock, on the Norway coast (where this species is more abundant than our own), the flesh of which they had almost entirely consumed. It is usually from twelve to fifteen inches in length, and of the thickness of the little finger; and its whole tissues are so soft, that it would not have been supposed capable of inflicting any serious injury. The quantity of mucus which it can secrete from its surface is enormous; it has been asserted, that if a Hag be placed in a pitcher of sea-water, it will speedily convert this into a semi-transparent jelly; and that, if placed in a fresh quantity of water, it will change this in the same manner. The most imperfectly formed of all Fish is, probably, the *Amphioxus*, or *Lancelot;* which has, by many Natu-

ralists, been removed altogether from the Vertebrated sub-kingdom, on account of the almost complete absence of what are usually regarded as the distinguishing peculiarities of that group. Nevertheless, an attentive examination of its structure shows, that it bears a closer resemblance to the true Fishes than to any other animals—exhibiting their conformation in (as it were) a degraded form. It is of very diminutive size, scarcely an inch in length, very slender, and almost transparent. The body is compressed laterally; and there are no pectoral, ventral, anal, or caudal fins, but only a single dorsal fin, extending the whole length of the body. There are no eyes, nor any vestige of any external organ, except a mouth, which is surrounded by small tentacula, like that of the Hag. There is scarcely any trace of a vertebral column, or of ribs; yet the muscles are arranged with great regularity, on the plan of those of Fishes in general. One of the most curious parts of its structure is the complete absence of cerebral hemispheres, and even of ganglia of special sense; the spinal cord being, apparently, the only centre of its nervous system. Thus it may be characterised as one of those "experiments prepared for us by Nature;" exhibiting to us a case, in which the Cerebrum is never developed; the phenomena of which closely correspond with the results that have been obtained by the artificial removal of that organ. (ANIM. PHYSIOL. § 465.)

586. The Geological distribution of this class presents many points of the greatest interest to the Zoologist. As might have been anticipated from what is known of the history of the production of the present crust of the globe, we find remains of Fishes in the very earliest formations which distinctly exhibit the action of water, —that is, which were deposited as sediments in the bed of the ocean; and this long before we have reason to believe that any land animals existed upon the surface of the globe. But the Fishes of this early date were, for the most part, formed upon a very different plan from those of the present epoch, so that there are very few of those now existing, which bear any close resemblance to them; whilst, on the other hand, the greater proportion of

the species now existing had no representatives among those, which inhabited the primeval ocean. Many of the latter are known to us only by their scaly coverings, which are frequently preserved with the greatest perfection, when the internal skeleton has disappeared,—the scales having the hardness of bone or even of enamel, whilst the skeleton was cartilaginous.—As we ascend towards the newer formations, which are nearer the surface of the earth, we find the character of the class gradually changing,—the forms, which were predominant in the older rocks, disappearing one after another, and being replaced by others, which bear more resemblance to those now existing. It has been discovered by Professor Agassiz, who has devoted a large part of his life to the study of Fossil Fish, that there is a constant correspondence between the character of the scales and the internal organisation of the fish; and he has proposed that the arrangement of the class shall be founded in the first instance upon the form and structure of the Scales. This classification has not yet been received amongst Naturalists, as superseding that of Cuvier; but the advantages which it presents, in regard to the study of Fossil Fishes, give it a claim to our attention. —According to Professor Agassiz, all Fishes may be arranged under the four following groups:

I. Ganoidians; from the Greek γανος, *splendour*.—The Fishes of this order are covered by angular scales, composed internally of bone, and coated with enamel. The scales are *regularly* arranged, and entirely cover the skin with an almost impenetrable armour.—This order includes the *Sauroid* fish (§ 588), of which the Sturgeons and the Lepidosteus are the only existing representatives; together with many other peculiar forms, to which we have nothing at all analogous among the Fishes now existing.

II. Placoidians; from the Greek πλαξ, *a broad plate.*—This order contains Fish whose skin is covered *irregularly* with plates of enamel, often of considerable dimensions, but sometimes reduced to small points, like the shagreen on the skin of the Shark, and the prickly tubercles of the Ray.—Among existing fish, this order comprehends only the Sharks and Rays and their

allies; but these form but a very insignificant part of the species which are to be referred to it.

The two preceding Orders are further characterised by the peculiarity in the form of the tail, which has been pointed out in the Sturgeons (§ 581); and which, among the existing fishes, is confined to that family, with the Sharks and Rays, and the Lepidosteus.

III. CTENOIDIANS; from the Greek κτεις, genitive κτενος, *a comb.* The Ctenoid fish are covered with horny or bony scales, jagged like the teeth of a comb on the outer edge. The *Perch* and many other existing genera are examples of this order, which contains but few fossil forms.

IV. CYCLOIDIANS; from the Greek κυκλος, *a circle.*—The Fish of this last order have their scales smooth and simple at the margin, and often ornamented at the upper surface. The *Herring*, *Salmon*, &c., are referred to the Cycloid order; which, with the preceding, includes all the existing species, with the exception of the few that have been already mentioned as belonging to the preceding groups.

587. Now the Fish of the oldest or Palæozoic strata belong almost exclusively to the *first* of these divisions; and of eighty species of Ganoid fish,—which are all that have been hitherto described,—upwards of fifty are exclusively met with in the Old Red Sandstone formation alone. Many of the forms presented by these are most extraordinary,—being totally unlike any with which we are acquainted among existing species,—and indicating an obvious mixture or combination of the characters of the class of Fish with those of the Crustacea. Indeed in regard to the real nature of some of the species discovered a few years since in Scotland, even Agassiz was at first undecided,—so strong was the resemblance presented by them to certain forms of Crustacea, especially the *Trilobites* hereafter to be described (§ 764); and it was not until connecting links were discovered, in which the distinctive characters of the true Fish were more obvious, that the nature of the first could be certainly determined. The head and body of many of these fish were covered by large hard plates; whilst the internal skeleton, from the

entire absence of any remains of it, seems to have been composed of soft cartilage. In the *Cephalapsis* (or buckler-head), the head was very large in proportion to the body, occupying one-third of its length, and being rendered of enormous breadth by two crescent-shaped wings, extending backwards and outwards. In the *Ptericthys* (or winged fish), the plates both of the head and body were very large, and consequently few in number; it was furnished with a pair of wing-like fins, placed far forwards, and terminating in a kind of hook, or strong curved point; and the tail, which occupied more than a third of the total length of the animal, was straight, pointed, and covered with small tuberculated angular scales. "Most probably the tail was employed as the principal organ of locomotion; the pointed fins being elevated at the approach of danger, and the animal in this way rendering itself as unapproachable and as difficult to be swallowed as its form would admit of." The *Cocosteus* had a body of triangular shape, tapering away towards the tail; and was covered almost entirely by a central plate, much larger than any of the others, having a continuous ridge along the middle of the back; it was also furnished with a couple of defensive fins, situated near the head, like those of the Ptericthys. The tail evidently possessed a vertebrated structure; and it was by this that the animal was most certainly recognised as a Fish,—its jaws and teeth having more the characters of the nippers of a Lobster or the mandibles of a Beetle. The teeth were chiselled, as it were, out of the solid bone of the jaw; just as the teeth of a saw are cut out of a plate of steel: and the line of opening of the jaws was *vertical*, as in the Articulata, instead of being *horizontal*, as in the Vertebrata. Remains of this fish are found very abundantly in some situations; varying from a few inches to two feet in length.—The other Fishes of the Palæozoic epoch were, for the most part, less widely different from those of the present day; one remarkable genus may be mentioned, the *Holoptychius*, which exceeded most of the others in size, and was evidently adapted to prey upon them. The name of this fish is derived from the large undulating furrows marked upon the surface of its enamelled scales, which give them a most beautiful appearance; these scales,

by their strength and magnitude, seem as if they might have served for the armour of a Crocodile ten times the size of the fish. Its head, also, was inclosed within bony plates, whose upper surface was covered with rough tubercles of enamel; and the jaws, likewise, were composed of bone, whose outer surface was polished, covered with enamel, and unclothed with skin. A row of thickly-set pointed teeth fringed the enamelled edges of the mouth, and corresponded to the lips of ordinary fish; whilst within this was a second and wider range of teeth, at least twenty times the bulk of the others. This, and some other allied genera, were evidently the "pirates" of their day; the extraordinary armature of their jaws being in conformity with the remarkable defences, with which the bodies of the fishes that served for their prey were endowed.

588. As we pass from the Old Red Sandstone into the newer rocks, we meet with a change in the characters of the Fish, whose remains are imbedded in them. All those just described, with the exception of the last, disappear; and they are replaced by others. Still we find that of the Fish contained in the Mountain Limestone and the beds associated with it, a large proportion belonged to the order Ganoidians; but, among these, the *Sauroid* fishes now predominate. These are at once distinguished by the peculiar form of their teeth; which are marked by longitudinal furrows like those of Crocodiles; and which have a conical hollow at the base, in which the next tooth is prepared, as in many Reptiles. So strong, indeed, is the resemblance of both the teeth and scales of several of the Fishes of this group to those of some Crocodilian animals, that, when first discovered, they were immediately referred to that class. The dimensions of the teeth of the genus *Megalicthys* (large fish), far exceed those of any other fishes' teeth that have been yet examined; one of them having been found to measure nearly four inches in length, with a breadth at the base of nearly two inches. The large teeth are accompanied by several very small ones, which alternated with them, and were distributed over the whole of the inside of the mouth. Scales of this fish have been met with as much as five inches in diameter.

There is some reason to think, from the character of the other fossils with which its remains are associated, that this Fish was an inhabitant of fresh water, like the comparatively diminutive Lepidosteus of the present day (§ 572). The Sauroid fishes predominate in an increasing degree among the genera of the Ganoid order, as we rise through the newer strata; and at last they become the only representatives of that order. It is between the Oolitic and Chalk periods, that we find the most remarkable change in the proportion which the Fishes of this group bear to those of other orders; for, whilst the Oolite includes the remains of numerous fishes of the Ganoid order,—many of them Sauroid fishes of great size and strength,—we find but very few in the Chalk and later formations, and even these are of diminished size and ferocity; so that, by this gradual change, the order has now become nearly extinct, as already mentioned.

589. It is in the strata of the Carboniferous order, or the Mountain Limestone and the overlying beds of the Coal series, that we encounter the first appearance, in any considerable proportion, of the Fishes of the Second order, or *Placoidians*. These do not depart so widely from the forms with which we are familiar at the present day, as did the earlier Ganoidian Fishes; but it is interesting to remark, that the greater number of the early Placoidians did not bear a resemblance to the Sharks and Rays which are most abundant at the present time, but to some that are now regarded as aberrant forms, separated from the rest by peculiarities of conformation. This is the case, for example, with the *Cestracion Philippi*, or *Port-Jackson Shark;* which has the margins and inner surface of the jaws covered with flat pavement-like teeth, disposed in an oblique row; whilst the front of the mouth is armed with sharp, angular, and pointed teeth, more resembling those of the ordinary Sharks. The latter are evidently adapted for seizing and retaining the food; the former for crushing and bruising it. These teeth are rarely found connected together in a fossil state. Now, of the fossil Fishes presenting these peculiarities, and referred on that account to the family *Cestracionts*, remains are found even in the

Palæozoic strata; they become more numerous in the Carboniferous series; they are very numerous in the Lias and Chalk formations; but there they cease almost entirely,—the strata of the Tertiary series scarcely containing any of them, and the Port-Jackson Shark being the only representative of this family at the present day.—Intermediate between these and the ordinary Sharks was another family, to which the name of *Hybodonts* has been given. The teeth of this division were stronger and blunter than those of the true Sharks, but were not so much flattened as those of the Cestracionts; and they seem to have been adapted for cutting, tearing, and bruising substances of considerable hardness. The Fishes of this family seem to have made their first appearance in the later part of the Coal formations; they were very abundant during the Oolitic period; but ceased entirely at the commencement of the Chalk deposit.—Lastly, the ordinary Sharks, constituting the *Squaloid* family, which are distinguished by their sharp lancet-like teeth, have no representatives among the Fossil Fishes of older date; but their remains are first found in the Chalk formations, and extend through all the newer strata down to the present time.—The *Rays*, also, of the earlier periods had teeth more flattened than those of later epochs; and we find from their fossil remains, that some of the forms, which are now regarded as exceptional or aberrant, were formerly more abundant. Thus of the *Myliobatis* or Eagle-Ray (§ 584), of which five species are at present known, fifteen fossil species have been discovered.

590. The *Ctenoid* and *Cycloid* Fishes make their first appearance in the Chalk formation; when all the previously-existing genera of the Ganoid and Placoid orders had become extinct, and when the new ones that were brought into existence were (as we have seen) far less numerous than before. There is, then, a sort of boundary line at the base of the Cretaceous or Chalk deposits, which divides the class of Fishes in a most remarkable manner;—all those below that line, in the order of the strata, or (in other words) all those which existed at a period anterior to the deposition of the Chalk, having belonged to the two first orders, those with enamelled scales;—whilst by far the

larger proportion of those existing at a subsequent time, as at the present epoch, belong to the two orders with horny scales, which comprehend at least three-fourths of the 8000 living species of Fishes known to Naturalists. Of the fossils of these last orders, which abound in the formations of the Tertiary period, it is sufficient to say, that they may nearly all be referred to *families* which have been described as now existing; that many of them belong to the same *genera* with recent Fishes; but that it is doubtful if any of them are of the same *species* with those now tenanting our seas.

591. The sketch here given of the principal groups of Fossil Fishes, is sufficient to illustrate some very interesting points in the history of this class. In the first place, we see that the first-created Vertebrated animals so far resembled the Invertebrated classes, as to possess a very dense external skeleton; whilst their internal skeleton was so soft, as not to be capable of being preserved; and it appears to have been to the Crustacea, which are among the highest of the Articulated series, that these Fishes were most nearly related. On the other hand, among the Fishes of the present time, the *Cyclostomata*, which present the characters of the Vertebrata in their most imperfect form (§ 585), are rather analogous to the *Annelida*, or *Worm* tribe; with which, indeed, some of them were actually classed by Linnæus.—We may next observe, that the covering of dense enamelled scales, in which all the Fishes of the earlier formations were inclosed, rendered necessary a peculiar conformation in the mouths of those, which were destined to prey upon them and to restrain their multiplication. Thus we find the mouths of the predaceous Ganoid fishes, such as the *Holoptychius* and its allies, and in those of the *Cestracionts* and *Hybodonts*, a pavement-like covering of flat enamelled teeth, adapted to crush the hardest substances. But when the enamelled-scaled Fishes had given place to those furnished with a softer covering, we find these enamelled pavements of the jaws replaced by sharp cutting teeth,—the predaceous Ganoids disappearing altogether, and the Cestracionts and Hybodonts giving place to the Sharks.—What was the purpose for which all the earlier races of Fishes were provided

with the enamelled covering so often alluded to, and why these races should have given place at a later period to others so differently constituted, we have no certain means of knowing. It has been suggested by Dr. Buckland, that the purpose of this cuirass may have been, to defend the bodies of the animals against waters that were warmer, or subject to more sudden changes of temperature than could be endured by animals, whose skin was protected only by such thin and often disconnected coverings, as the membranous and horny scales of most modern Fishes. Such changes of temperature were more frequent, there is good reason to believe, in the earlier epochs of the Earth's history, than they are at the present time, for reasons which will be elsewhere explained. (See Treatise on GEOLOGY.)

592. It may be further remarked, that the history of the Fossil Fishes most clearly proves, that the first-created forms of Animal life were not the least perfect,—as some have maintained; and that there is not a regular succession of new races, increasing in elaborateness of structure, from the oldest to the most recent formations. For among the earliest races of Fishes, we find that those of the Sauroid family, which had many characters of *elevation,* held a conspicuous place; and that, when these were replaced by the class of Reptiles, which was called into existence as soon as there was any land for its habitation, they ceased to exist, and were succeeded by races of Fishes which must be regarded as lower in the scale.

CHAPTER VII.

GENERAL CHARACTERS OF ARTICULATED ANIMALS.

593. The animals of which is composed the Sub-Kingdom Articulata, not only present an internal structure which is essentially different from that of the other three divisions of the Animal series, but are likewise distinguished by external characters, which are usually so definite and evident, that they may be almost always recognised at the first glance. Their entire body, in fact, is divided (more or less obviously) into segments; and seems to be composed of a series of rings placed in a line. In some Articulated animals, this *annular* (ring-like) appearance results merely from a certain number of transverse folds, which furrow the skin, and encircle the body; but in the greater number, the animal is enclosed in a sort of solid armour, composed

Fig. 287.—Iulus.

of a series of rings, united one to another in such a manner as to allow them a certain degree of movement. This envelope has uses analogous to that of the internal framework of Vertebrated animals; for it determines the general form of the body; it protects the soft parts; it gives points of attachment to the muscles; and furnishes them with levers, by their action on which the movements may be effected with precision and rapidity. Hence it may be termed an *external skeleton.* It must be borne in mind, however, that the hard substance of which it is composed has no analogy in structure, or in

mode of growth, with the *bones* of Vertebrated animals. It consists, in fact, of the *skin*, consolidated by the deposition of horny or calcareous matter in its substance; and instead of being able to grow in all directions in the manner of bone, it undergoes very little change when it is once fully formed, and it cannot be made to increase in size except by addition to its edges.

594. The different rings, or segments, of the body of an Articulated animal, always bear a strong resemblance to each other; and sometimes, as in the *Iulus* (Fig. 287), and the *Scolopendra*, or *Centipede*, they seem like actual repetitions of each other.

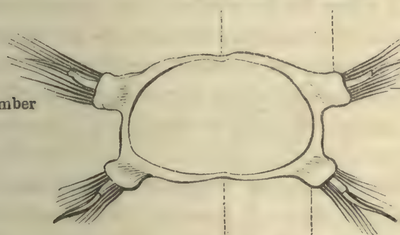


FIG. 288.—VERTICAL SECTION OF A SEGMENT OF AN ANNELIDE, BELONGING TO THE GENUS AMPHINOME.

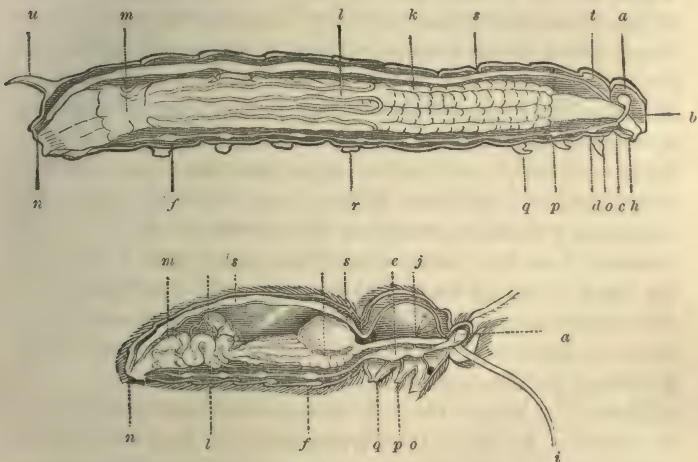
Each ring may bear two pairs of appendages, or members; the one belonging to its *dorsal* arch, or the upper part of the segment; whilst the other belongs to the *ventral* arch, or the under part of the ring. In those Articulata in which the principle of "division of labour" does not yet manifest itself,—that is, in whose bodies we find a number of similar parts adapted to perform the same functions, instead of an assemblage of different parts, constructed each for its own special purpose,—all the segments are provided with these appendages, and their number is sometimes extremely great. But in all the higher tribes, we find the appendages of certain segments attaining a high degree of development; whilst, by a sort of compensating principle, the others present themselves as mere rudiments, or are not even at all discoverable. In general the appendages of the ventral arch are alone developed; and the variety of forms which they

present is greater, in proportion as the animal is more elevated in the scale. Thus we find them so modified as to become *antennæ*,—those long, horn-like filaments, with which the head is furnished in Insects and Crustacea,—or to be subservient to mastication by being converted into jaws, or to take the form of legs, swimming organs, &c. Of this metamorphosis we shall hereafter notice some remarkable examples in the class Crustacea. Sometimes, however, the appendages of the dorsal arch are present throughout, and perform, like those of the ventral arch, the functions of limbs; of this we find many examples amongst the Annelida. But in general, no more than two pairs present themselves; these are situated on the segments constituting the centre of the body; and they perform the functions of wings or of analogous organs; as we shall hereafter see, when speaking of the class of Insects. The legs are generally 6, 8, 10, or 14 in number; sometimes many hundreds may be counted; and sometimes they are altogether deficient; but when they exist at all, they are never fewer than six, which is the number that is characteristic of the class of Insects. Sometimes instead of distinct legs, we meet with strong bristly appendages, as in the Earth-worm; or bundles of such bristles, in the midst of which one is occasionally a *cirrhus* or tendril-like appendage, constituting a sort of rudimentary leg, as in many Annelida (Fig. 288.)

595. The tendency to repetition exhibited by the segments of the body, is as remarkable in the disposition of the muscles and of the nervous system, as it is in the arrangement of the general envelope. In most animals of this Subkingdom, each ring in its complete state possesses a pair of nervous ganglia, united on the central line; and these ganglia are connected together by a double cord of communication, which runs along the lower or ventral surface of the body. In the inferior Articulata, and even in the highest, previously to the completion of their development, these ganglia are nearly

Fig. 289.—Nervous System of an Insect.

equal, and form with their connecting filaments two chains resembling knotted cords, extending from one end of the body to the other. (Fig. 290.) But in proportion as we rise in the scale, we see the ganglia approach one another, both sideways and length-



FIGS. 290 and 291.—Anatomy of the Caterpillar and Moth of the Privet: *a*, cephalic ganglia, situated in front of the œsophagus, and giving origin to the nerves of the eyes, &c.; *b*, cords which unite these ganglia to those of the second pair, passing on either side of the œsophagus, so as to form a collar round it; *c*, first pair of sub-œsophageal ganglia; *d*, ganglion of the first segment of the thorax, followed in the Caterpillar by others at regular intervals; *e*, nervous mass in the Moth, formed by the ganglia of the second and third thoracic segments; *f*, abdominal ganglia; *h*, mouth; *i*, trunk; *j*, œsophagus; *k*, stomach; *l*, intestine and biliary vessels; *m*, large intestine; *n*, anus; *o*, legs of the first pair; *p*, legs of the second pair; *q*, legs of the third pair; *r*, first pair of membranous legs, in the Caterpillar; *s*, dorsal vessel; *t*, first segment of the thorax; *u*, horny appendage at the extremity of the abdomen of the Caterpillar.

wise; so that each pair unites on the central line into a single mass; whilst the ganglia of different segments are also brought together into one spot, and so combined as to form but one large ganglion,—as we shall hereafter notice especially among the Crustacea. This *centralization* is sometimes carried so far, in certain Crabs for example, that there exist in the whole body but two nervous masses,—one in the head, and the other in the thorax (Fig. 46[illegible]). The ganglia which we find in the head of Articulata have a

manifest correspondence to those of certain parts of the brain in Vertebrata. They are *not* the representatives of the Cerebral hemispheres, which are peculiar to the latter; but they obviously resemble the Optic and other ganglia of special sense, which we find even in the highest Vertebrated animals, at the origin of the nerves that proceed to those organs, and which in Fishes make up so large a proportion of the entire brain, as frequently to surpass in size the cerebral hemispheres themselves (§ 530). The ganglia of the ventral cord are so many centres of *reflex* action to the different segments which they supply (ANIM. PHYSIOL. § 442); and in this respect they are analogous to the Spinal Cord of Vertebrated animals, from which they differ in no important particular, except in their position. Even in this, however, there is a greater resemblance than is at first apparent; for there is strong reason for regarding the usual position of Articulated animals as really *inverted;* that is, for considering what is apparently the *ventral* surface of the body as in reality the *dorsal*, and the apparent *back* as the real *abdomen*.

596. The bulk of the body in the Articulata is made up of the muscles, by which the several segments, and their various appendages, are put in motion. These muscles, like the parts of the body themselves, are arranged with great regularity and exactness on the two sides of the median or central line; so that the *lateral symmetry* (§ 47) of the Articulata is most exact. We shall hereafter see that this symmetry extends in great degree also to the organs of nutrition; which in the Vertebrata are not arranged with the same equality. Where the segments and their appendages have a similar form and action, their muscles are but repetitions of each other; but where, as in the higher Articulata, the segments and their appendages are differently constructed, the muscles also are more variously arranged, and often form a system of great complexity.

597. The development of the organs of Nutrition in Articulated animals would seem to be altogether subservient to that of the Locomotive apparatus;—their function being chiefly to supply the nerves and muscles with the aliment necessary to sustain their vigour. The power of these muscles is so great in propor-

tion to their size, that, in energy and rapidity of movement, some of the Articulated tribes surpass all other animals. These movements are directed by organs of sensation; which, although not developed on so high a plan as those of some Mollusca, are evidently very acute in their powers. There are very few instances of Articulated animals being in any way restrained as to freedom of locomotion; and these are for the most part found in a single group, the CIRRHIPODA, or *Barnacle* tribe, which connects this sub-kingdom with the preceding. In general they roam freely abroad in search of food; and they are supplied with prehensile organs for capturing their prey, and with a complex masticating apparatus for reducing it. Their actions are evidently directed almost solely by *instinctive* propensities, which are adapted to meet every ordinary want; these are of similar character in each individual of the same species, and present but little appearance of ever being modified by Intelligence. Hence these animals seem almost like machines, contrived to execute a certain set of operations; many of them, however, producing immediate results, which even Man, by the highest efforts of his reason, has found it difficult to attain.

598. All the Articulata, save a few of the very lowest species, possess a distinct head at one end of the body, furnished with organs of special sensation, and with jaws for the prehension and reduction of the food. These jaws do not open *vertically*, however, as in the Vertebrata, so as to leave a horizontal aperture; but *laterally*, so as to leave a vertical aperture: and there are frequently several pairs of them, one behind the other, sometimes furnished with sharp cutting edges, sometimes having their edges toothed like a saw, and sometimes adapted to crush rather than to cut or tear. The alimentary tube frequently passes straight along the central line, from one extremity of the body to the other, with a dilatation near its commencement,—the stomach: and where this is not the case, the convolutions which the intestine makes are usually few in number. Instead of a heart, we find a *dorsal vessel* (*s*, Figs. 290 and 291), a long tube placed on the central line of the back, and divided into segments, corresponding with those of the body,—each seg-

ment being, as it were, the heart for its own division. The respiratory apparatus, too, is arranged with the most perfect symmetry. In the lower tribes, and in the Crustacea, it is adapted to act in water; and consists of gills or branchial appendages, of various forms, which are prolonged from the exterior of the body. But in Insects and Spiders, which constitute the great majority of the class, the respiration is aerial; and is performed by an apparatus consisting of a set of chambers or tubes, which are dispersed or extended through the whole body. By this means, the air, the blood, and the tissue to be nourished, are all brought into contact at the same points; and a much less vigorous circulation is required, therefore, than would otherwise be needed. The whole apparatus of Nutrition is comprised within a comparatively small part of the body, in the higher classes at least; and the bulk of the organs composing it is never to be at all compared with that, which we ordinarily find in the Mollusca. Thus the Liver, which in the Oyster forms a large part of the whole substance, is often scarcely discoverable in the Insect; and where (as in the Crustacea) its bulk is considerable, it is because the respiration, being aquatic, is less active than usual, and is consequently not sufficient to draw off the superfluous carbon from the blood (Anim. Physiol. § 365). The blood is usually white, as in other Invertebrated classes; and where it is otherwise (as in some of the Annelida), it is in the liquor sanguinis, and not in the corpuscles, that the colour exists,—these last being analogous to the *colourless*, and not to the *red* corpuscles of the blood of Vertebrata. The temperature of Articulata usually varies with that of the air or water they inhabit; but in the class of Insects we find many, which have the power of generating a large amount of independent heat; and this is strictly proportional to the quantity of oxygen converted by them into carbonic acid, by the respiratory process. All the actions of the Articulata are performed with great energy; and at the time of the most rapid increase of the body, the demand for food is so great, that a short suspension of the supply proves fatal. Many of them, however, are capable of being submitted to the influence of very high and of very low temperatures, with little permanent injury.

599. The division of this Sub-kingdom into Classes, is principally founded on the organs of locomotion; which, as we have seen, are so characteristic of it. We may first form two groups, distinguished by the presence, or absence, of *distinctly-articulated members*. In the former, the locomotive power is for the most part consigned to these appendages; and the trunk is usually encased in a hard envelope, in which, by the union of segments that were originally distinct, we sometimes almost lose the traces of the characteristic division. This is especially the case with the Crab and its allies; in which the different parts of the body are quite immoveable upon each other. On the other hand, in the lower group, in which distinct members are wanting, the locomotion of the animal is chiefly effected by the movement of the body itself; and this is permitted to the utmost extent, by the softness of the integument, in which the intervals of the articulations are scarcely distinct from the rings themselves,—as in the Leech or Earth-worm,—so that here, too, the division into segments becomes indistinct, from the opposite cause. It is in the Centipede (Fig. 292) that we have the best example of the division of the body into segments, which is characteristic of the entire group; together with an articulated structure in the limbs. In the classes of Insects, Crustacea, Spiders, &c., the equality of the segments disappears; whilst in the Leech and Worm tribes, the members disappear.

Fig. 292.
Centipede.

600. The higher division of the Articulated series may be arranged into the following classes:—

I. Insects; characterised by the division of the body into *three* distinct portions,—the head, thorax, and abdomen; by the possession of antennæ on the head, of *three* pairs of legs, and (in general) of one or two pairs of wings; and by their aerial respiration.

II. Arachnida, including the *Spiders*, *Scorpions*, and *Mites*;

characterised by the division of the body into *two* distinct portions, the cephalo-thorax (made up of the head united to the thorax) and abdomen; by the possession of *four* pairs of legs; by their want of antennæ; and by their aerial respiration.

III. Crustacea, or *Crabs*, *Lobsters*, &c.; distinguished by their aquatic respiration; and by the possession of from *five* to *seven* pairs of legs; the body sometimes divided nearly as in Insects, sometimes even more concentrated than in the Arachnida, and sometimes formed on the plan of that of the Myriapoda.

IV. Myriapoda, the *Centipede* tribe; characterised by the want of distinction between thorax and abdomen; by the equality of the segments of the body,—the head, however, being very distinct; by the large number of legs, of which there are seldom less than twenty-four pairs; and by their aerial respiration.

Intermediate in some respects between the two divisions of this Sub-kingdom, we may rank the following remarkable group:—

V. Cirrhopoda, or the *Barnacle* tribe; in these, there are no locomotive members in the adult, although the young possesses them; there are, however, a series of jointed tendril-like appendages, which probably serve both for respiration and for the acquirement of food; and the animals remain attached to one spot, during all but the early period of their lives; their respiration is entirely aquatic.

601. In the Second division of Articulata, characterised by the absence of articulated members, we meet with but three classes.

VI. Annelida, the *Leech* and *Worm* tribe; characterised by the extension of the body into numerous segments, which present scarcely any differences from each other; by the presence of a distinct circulating system, and of respiratory organs; and by the possession of a well-developed nervous system.

VII. Entozoa, or *Intestinal Worms*, in which the Articulated form is presented in (as it were) a still more degraded state; the segments being yet more completely repetitions of one another, and often capable of existing separately; special organs of circulation and respiration being for the most part wanting;

and the nervous system being very indistinct,—never presenting the double ventral cord in a well-developed condition: these have very frequently no distinct head.

VIII. Rotifera, or *Wheel-Animalcules*, a group of minute animals, in which the Articulated structure is often very indistinct, and which are especially characterised by the possession of *cilia*, or little hair-like filaments, arranged in rows in the neighbourhood of the mouth, and serving by their movements, both for the acquirement of food, and for the aeration of the fluids of the body.

CHAPTER VIII.

OF THE CLASS OF INSECTS.

602. The class of Insects is pre-eminent, not only amongst the divisions of the Articulated series, but in the whole Animal kingdom, in regard to the number of distinct *species* which it includes; and it is probably unsurpassed by any, save the Infusory Animalcules, in regard to the number of *individuals* at any time existing on the earth's surface, which belong to the numerous and diversified races comprehended in it. The whole sub-kingdom of Vertebrated animals may probably be estimated as not containing above 30,000 species,—a number which is surpassed by the *Beetle* tribe alone; and we should be probably not far wrong in saying, that the number of species of the whole class, already known, exceeds that of all other animals put together. Moreover, on account of the small size of *all*, and the very minute size of a large proportion, of the animals belonging to this class, it is probable that the number of species already known is far surpassed by that which remains to be discovered. Even in our own country, new species of Insects are continually being discovered, by the industry of observers who devote themselves to this particular branch; and the number at present unknown must of course be far greater, in countries that have been less completely explored. Of the importance of this class in the economy of Nature, several striking proofs will be given hereafter.

603. The tegumentary skeleton of Insects, that is to say, the hard skin of these animals, sometimes preserves a certain degree of flexibility; but generally presents a consistency analogous to that of horn. It must not be thought, however, that its tissue is really of that nature; for Chemistry teaches us that it is composed of very different materials, and that a particular

substance named *Chitine*, forms the base of it ; but there is reason to believe, that it possesses a definite organic structure ; and that it consists of one or more layers of cells, in the cavities of which this substance is deposited. We see in it a great number of pieces, which are sometimes soldered (as it were) together ; whilst in other instances they are united by soft portions of the skin, and thus possess a greater or less freedom of motion.

604. The body of the Insect, as we have already said, is divided into a certain number of rings, placed end to end ; and

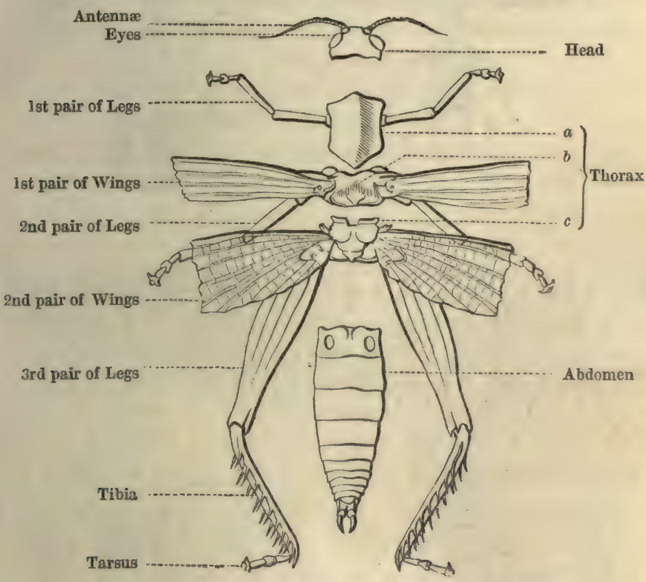


FIG. 293.—ANATOMY OF THE EXTERNAL SKELETON OF AN INSECT.

in this series of segments, we distinguish three portions, to which are given the names of *Head, Thorax*, and *Abdomen*. The members or appendages which spring from the several segments, have a structure analogous to that of the trunk of the animal: being composed of tubes or of hollow plates, placed end to end, and enclosing in their interior the muscles and nerves destined to put them in motion.

605. The head is formed only by a single piece; and bears the eyes, the antennæ, and the appendages of the mouth. The *antennæ* constitute the first pair of members or appendages of Insects; and are composed of a considerable number of small joints placed end to end; they arise from the anterior or superior part of the head; and generally have the form of slender and

FIG. 294.—CAPRICORN BEETLE.
a, a, antennæ.

FIG. 295.—PAUSSUS CORNU.

flexible horns (Fig. 294, *a a*); but their conformation varies much, especially amongst the males; thus they sometimes resemble feathers, sometimes saws; at another time small bulbs (Fig. 295); and in other instances they are terminated by an enlarged part composed of layers placed like the leaves of a book. Their length is sometimes very considerable. We know nothing positive regarding their use; but it is supposed that they are

FIG. 296.—VARIOUSLY-FORMED ANTENNÆ OF INSECTS.

organs of feeling, and perhaps also of hearing (ANIM. PHYSIOL. § 498). Other appendages, to the number of three pairs, spring

from the inferior part of the head, and constitute the organs of mastication or of suction ; we shall return to these, when speaking of the Digestive apparatus.

606. The *thorax* of Insects occupies the middle part of their body ; and bears the legs and the wings. It is always composed of three rings, named *prothorax*, *mesothorax*, and *metathorax* (Fig. 293, *a*, *b*, *c*) ; and to the ventral arch of each of these segments, is fixed one of the pairs of legs. The wings arise, on the contrary, from the dorsal arch of the thoracic rings ; but the prothorax never bears them, and there never exists more than one pair of these appendages on each of the succeeding rings ; so that their number can never exceed two pairs.

607. We may distinguish, in the limbs of Insects, a haunch composed of two joints, a thigh, a shank, and a kind of finger, named *tarsus*, which is divided into several joints whose number varies from two to five, and is terminated by claws. Their conformation differs ; but, as may be readily believed, it is always in relation with the habits of the animals. Thus the Insects whose posterior legs present a great length (Fig. 297), usually jump rather than walk ; amongst the swimming insects, such as the *Dytiscus*, the *Notonecta* (Fig. 298), and the *Gyrinus*, vulgarly called Whirligigs (Fig. 299), the tarsi are usually flattened, fringed with hairs, and arranged like oars ; and amongst

FIG. 297.—LOCUST.

FIG. 298.—NOTONECTA.

FIG. 299.—GYRINUS.

those which can walk suspended from smooth surfaces, we find, under the last joint of these organs, a kind of cushion or cup, fitted to make them adhere to the body which they touch. Sometimes, also, the anterior legs are widened like those of the Mole, in order to enable them to dig in the ground ; the *Mole-Cricket*, which often occasions considerable injury in our fields,

by cutting the roots which it finds in its way, presents us with a remarkable example of this form of structure. There also

FIG. 300.—MOLE-CRICKET.

exist some species, amongst which these same limbs constitute organs of prehension, the leg being disposed in the manner of a claw, and being able to bend itself back against the preceding

FIG. 301.—MANTIS RELIGIOSA.

joint, of which the edge is armed with spines. A large insect from the South of France, the *Mantis religiosa*, is formed in this manner. Again, we meet with some insects, amongst which the anterior legs are reduced to a rudimentary state, and bent back against the thorax, no longer serving for its movements, and easily escaping notice, so that at first sight we should believe these animals were provided with only four legs; several diurnal Butterflies are in this condition (Fig. 302).

FIG. 302.—MORPHO.

608. The wings of Insects are leaf-like appendages, composed of a double membrane, supported on the inside by a more solid framework. When they are but slightly developed,

they are soft and flexible; but they soon dry up, and remain stiff and elastic. In general there are two pairs; we never find a greater number, but sometimes one or other of these pairs is wanting; and it is always from the last two rings of the thorax that they arise. Their form varies; when they really serve for flight, they are thin and transparent, except when lightly covered with a kind of coloured dust, formed by scales of a microscopic minuteness, such as we see amongst the Butterflies; but often those of the first pair become thick, hard, and opaque, and constitute a kind of sheath or casing, named *elytra* (*a*, Fig. 303), which, in a state of rest, covers over the membranous wings (*b*), and serves to protect them; at other times these same wings, still membranous at their extremity, become hard and opaque towards their base, and are then designated under the name of demi-casings or *hemelytra*. We are acquainted, also, with some insects, amongst which the wings, instead of having a leaf-like structure, are divided into a number of membranes, barbed along the edges, so as to resemble feathers arranged in a fan-like manner; this is seen in a genus allied to the Butterflies, and known under the name of *Pterophorus*, or *Plumed-Moth*.

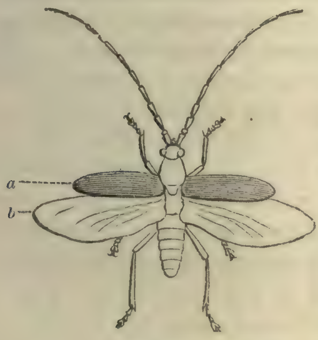


Fig. 303.

Fig. 304.—Pterophorus.

Fig. 305.—Conops.

Again, when the posterior wings are wanting, they are generally

replaced by two small moveable threads, thickened at the end, which are called balancers (Fig. 305).

609. The abdomen of Insects is composed of a considerable number of rings, moveable upon each other; we can frequently reckon nine of these; but at other times we cannot distinguish so many; this appears to depend on the union of two or more of these segments with each other. In the perfect Insect, these rings never bear any legs or wings; but those which occupy the posterior extremity of the body, often give attachment to appendages, whose forms and uses vary very much. Sometimes they are simple bristles, or points, whose functions are not well known; as in the *Ephemera* (Fig. 334) for example. Sometimes these organs possess the form of hooks; and constitute a more or less powerful pair of pincers, as amongst the *Forficulæ*, or Earwigs (Fig. 306). At other times they are so arranged, as to act as a spring, and to enable the animal to throw itself forwards; the *Poduræ*, or *Spring-tails*, — small insects, which, in our climate, conceal themselves under stones, or keep themselves on the surface of still water, and which also live sometimes in the snow of the coldest regions of the globe, show this mode of organisation.

Fig. 306.—Forficula.

Again, in other instances, these abdominal appendages have a more complicated structure, and constitute an offensive weapon, or an apparatus destined to effect the deposit of the eggs laid by the animal in a place fitted for the development of its young; as examples of these organs, we may mention the retractile sting of the Wasps and Bees, and the piercer of the Tenthredos, or Saw-flies. The former is composed of a dart, formed of two sharp-pointed processes, placed within a horny sheath, or case, and having in each a furrow (completed into a canal by the union of the two) through which the poison

Fig. 307.—Podura.

flows, that is secreted by a small gland which is situated very near. In a state of repose all these pieces are drawn within the body of the animal; but when the insect wishes to use it, he causes the sheath to project, and buries it, together with his dart, in the skin of his enemy. Sometimes it is even impossible for him to draw it out; the whole sting is then separated from the body, and remains fixed in the wound. The injury which results from this, quickly causes the death of the insect. The male is always destitute of this weapon; hence it may be seized without danger: but the females, and generally the sterile individuals, called *workers*, are provided with it: the puncture causes a painful inflammation.—The *borer* of the Ichneumons, of the *Fœnus* (Fig. 308), and of many other insects, shows an arrangement very analogous; and we generally observe in it a kind of small saw, by the aid of which the insect pierces the vegetable or animal tissues in which it desires to deposit its eggs. It is by thus piercing a species of oak, in the Levant, that the small insect, known by the name of *Cynips*, or Gall-fly, causes the formation of the Gall-nuts, of which so much use is made in the manufacture of ink, and in the preparation of black dyes. The small puncture effected by the *Cynips* causes an overflowing of the vegetable juices, and there soon results from this, an excrescence, in the centre of which we find the eggs, or larvæ, of the insect.

FIG. 308.—FŒNUS.

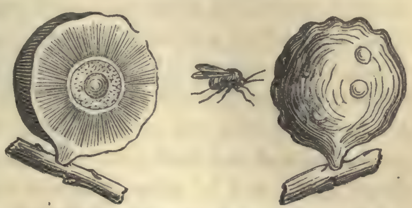


FIG. 309.—THE INK-GALL INSECT, AND THE INSECT BY WHICH IT IS PRODUCED.

610. Insects are provided with highly developed senses; they evidently possess Hearing and Smell, as well as Taste, Sight and Touch; but even now the seat of the sense

of Smell has not been certainly discovered; and amongst the greater part of these animals, no special organ of Hearing can be perceived. The antennæ, and the appendages of the mouth, seem to be the principal instruments for Touch; and the former may, perhaps, also serve for the perception of Sound. We also know very little of the apparatus for Taste; but the organs of Sight have been better studied.—The structure of the Eyes is very different from that which we have seen amongst the higher animals. In general, the organ which at first sight appears to be a single eye, is, in reality, formed by the aggregation of a multitude of small eyes, each having a cornea, a vitreous body of a conical form, a layer of colouring matter, and a separate nervous filament. In the common House-Fly, for example, we can reckon four thousand of these distinct eyes; and some insects are known, which have more than twenty-five thousand. All these little corneas are hexagonal, and are united together, so as to form a kind of common cornea, whose surface presents a number of divisions, resembling the meshes of a net, visible only by the aid of a magnifying glass. (See ANIM. PHYSIOL. §§ 573, 574). Moreover, each of the small eyes, which altogether make up these compound organs, is perfectly distinct from those which surround it, and forms with them a bundle of tubes, each terminated by a nervous thread proceeding from a bulbous expansion of the same Optic Nerve. Nearly all Insects are furnished with two of these compound eyes, usually placed on the sides of the head; but sometimes they are replaced by *simple eyes;* and in other instances these two sorts of organs exist together. The structure of simple eyes, which are known also by the name of *stemmata* or *ocelli*, has the greatest analogy with that of each of the elements of the compound eyes. The simple eyes are generally united in a group, to the number of

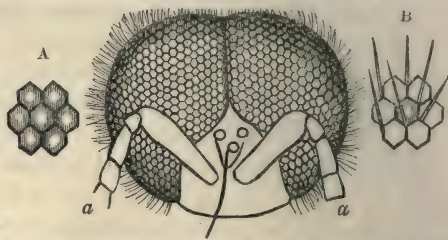


FIG. 310.—Head and eyes of the Bee: *a*, *a*, antennæ; A, facets enlarged; B, the same with hairs growing between them.

three, towards the top of the head. We know nothing certain of the manner in which these organs act upon the light that falls upon them; nor of the mechanism of vision amongst Insects.

611. Several Insects possess, in common with the higher animals, the faculty of producing sounds: but in general their song is not connected with the movements of the air in the respiratory apparatus, as amongst the former; and depends upon the rubbing of certain parts of the body against each other, or on the movements produced in certain special instruments, by the contraction of muscles. Thus the monotonous and deafening noise of the *Cicada* results from the alternate tension and relaxation of an elastic membrane, placed like the skin of a drum upon the base of the abdomen; amongst the Crickets, there are certain parts of the wings, which, when rubbed against each other, vibrate with intensity, and which have a very curious structure for this purpose; but the humming of Flies appears to depend upon the rapid exit of the air through the thoracic spiracles, during the violent movement of flight. Again, there are some Insects that utter a kind of cry, the manner of producing which is not well known; such is the *Sphinx Atropos*, known under the name of the Death's-head Moth. (ANIM. PHYSIOL. §§ 676—679).

FIG. 311.—CICADA.

FIG. 312.—SPHINX ATROPOS.

612. The Nervous system of Insects shows the general arrangement, and the chief part of the modifications, which we have already described in treating of the Sub-kingdom, to which these animals belong (§ 595). It is principally composed of a double series of ganglia, which are united together by longitudinal cords; the number of these ganglia corresponds with that of the segments; and they are sometimes at nearly equal distances, and extend from one end of the body to the other, whilst in other instances several of them are connected together in such a manner, as to constitute a single mass. The cephalic ganglia present a very high development, and give origin to the nerves of the Antennæ and of the Eyes, &c. The first pair of ganglia below the œsophagus supplies the nerves of the mouth; and the cords which unite these nervous centres to the cephalic ganglia, and which pass round the œsophagus, give off on each side a nerve which goes back to the stomach; and which joining itself with that of the opposite side, forms a single trunk, running on the central line above the digestive canal, and having two ganglia in its course. The three pair of ganglia on the ventral cord, following those which are situated immediately beneath the œsophagus, belong to the three rings of the thorax, and are the points of departure of the nerves of the feet and the wings; in general they are very close together, and are much larger than the succeeding pairs, which belong to the abdomen.

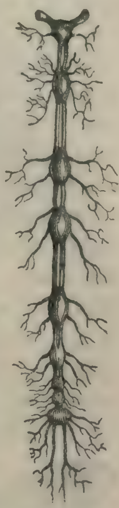


FIG. 313. NERVOUS SYSTEM OF INSECT.

613. The manner in which Insects are nourished, varies very much; some only live on the juices of plants and animals, others feed on solid food, and are either carnivorous or devourers of plants; and these differences correspond with remarkable modifications in the structure of the mouth. Amongst *gnawing* insects, such as Beetles, Cockchafers, Cockroaches, and Locusts, this opening is furnished in front with a central piece, named *labrum*, or upper lip (*a*, Figs. 314 and 315); and has on each side a kind of large tooth, moveable and very hard, called the *mandible*, or upper jaw (*b*),

which serves to divide the food. Immediately behind these mandibles is found a second pair of appendages, whose structure

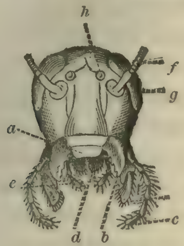


FIG. 314.
HEAD OF COCKCHAFER.
a, labrum; *b*, mandibles; *c*, maxillæ; *d*, tongue; *e*, labial palpi; *f*, antennæ; *g*, compound eyes; *h*, ocelli.

FIG. 315.—PARTS OF THE MOUTH OF CARABUS;—*a*, labrum; *b*, mandibles; *c*, maxillæ; *d*, labium.

is very complicated; these are the second pair of jaws, termed the *maxillæ* (*c*). Each of these last organs has on the inside a plate or cylinder, of greater or less hardness, generally armed

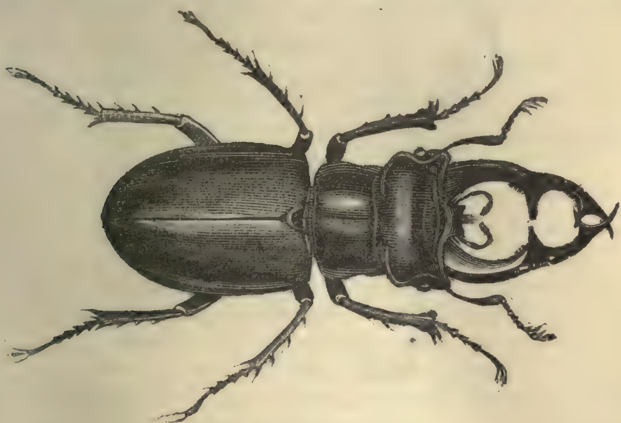


FIG. 316.—STAG-BEETLE.

with notches or hairs, and having on the outside one or two small appendages composed of several joints, and termed *maxil-*

lary palpi. Again, behind the maxillæ is found a second pair of appendages, whose base is supported by a central piece, called the *mentum*, or chin. These appendages constitute the tongue (*d*, Fig. 314); they are applied against the maxillæ, as these organs are themselves applied against the mandibles. We have further to mention a second pair of jointed moveable appendages, or palpi; which are termed *labial palpi*,—the name of *labium*, or lower lip, being commonly given to the piece formed by the union of the tongue and mentum (*d*, Fig. 315). The form of these various parts differs according to the nature and consistency of the food. The palpi serve principally for seizing the food, and holding it between the mandibles whilst these divide it. Sometimes the maxillæ have an enormous development, and form a large pair of pincers on the front of the head; an arrangement which is very remarkable among the Stag-beetles, and other species of the genus *Lucanus* (Fig. 316).

614. Amongst the *sucking* Insects, the maxillæ or the labrum are lengthened, so as to constitute a tubular trunk; in the

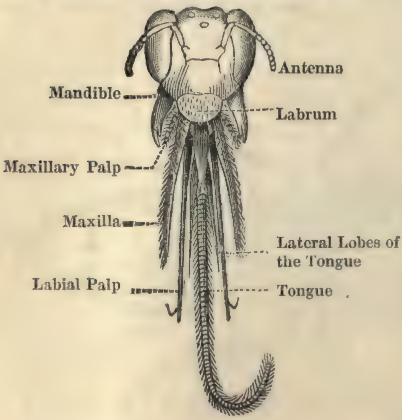


FIG. 317.—HEAD OF ANTHOPHORA.

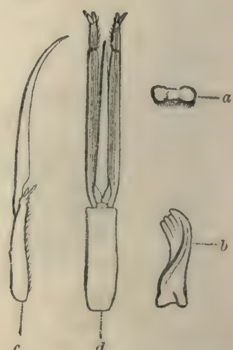


FIG. 318.—PARTS OF THE MOUTH SEPARATED.

interior of which we frequently find delicate filaments, performing the functions of small lancets, and formed by the mandibles and maxillæ modified to such a degree as to be hardly percep-

tible. Amongst the Bees, the Anthophoræ, or solitary Bees, the Humble Bees, and other Insects known by Zoologists under the name of *Hymenoptera*, the *buccal* apparatus * presents an arrangement, which is in some degree intermediate between these two extreme states. The labrum and the mandibles much resemble those of the gnawing Insects, and offer nothing very peculiar in their form and structure (*a* and *b*, Fig. 318); but the maxillæ (*c*) and the tongue (*d*) are greatly elongated; and the former have a tubular form, and inclose longitudinally the sides of the tongue; so that these organs, united into a bundle, form a canal that serves for the passage of the food, always soft or liquid, by which these Insects are supported. This tube is moveable at its base, and flexible during the remainder of its length; but it is never rolled up, as we shall find amongst the Butterflies. The mandibles serve only to divide the materials, of which the Hymenoptera make their nests; or else to seize and put to death the prey, whose juices these Insects suck. It is also to be observed, that there exist within the buccal cavity other solid pieces which are wanting amongst the gnawing insects; and which constitute valves destined to close the pharynx, whenever the movement of deglutition is not going on.

615. Amongst the Cicadæ, the Bugs, and other insects of the order *Hemiptera*, the apparatus for suction is composed of the same elements; but these present a somewhat different arrangement. The mouth is armed with a tubular and cylindrical proboscis, directed downwards and backwards (Fig. 319), and composed of a sheath inclosing four bristle-like prolongations, or setæ; the sheath (*a*, Fig. 320) is composed of four joints, placed end to end, and representing the labium or under lip; at its base we perceive a conical and elongated piece, which is analogous with the labrum; lastly, the *setæ* (*b*, *c*), which have the form of fine threads, stiff and jagged at their points to be

Fig. 319.—Bug.

* The term *buccal* refers to that which belongs to the mouth; and the above expression is conveniently applied to denote the several parts collectively, which altogether make up the mouth, in whatever way they may be arranged.

able to pierce the skin of animals or the vessels of plants, are the representatives of the mandibles and the maxillæ extremely elongated. In those Hemiptera which live at the expense of other animals, the proboscis is usually very firm, and folds into a semicircle under the head. Among those which are nourished by sucking vegetables, on the contrary, it is nearly always thin, and is laid when in a state of rest against the lower side of the thorax, between the feet. Its length is sometimes so considerable, that it passes backwards behind the posterior extremity of the abdomen.

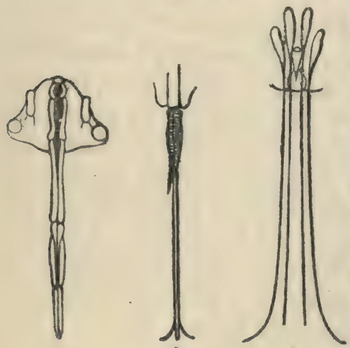


FIG. 320.—BUCCAL APPARATUS OF AN HEMIPTEROUS INSECT.

616. Amongst the Flies, also, the proboscis, which is sometimes soft and retractile, sometimes horny and lengthened, represents the under lip, and often bears palpi at its base ; a longitudinal channel occupies its upper side, which incloses the *setæ ;*

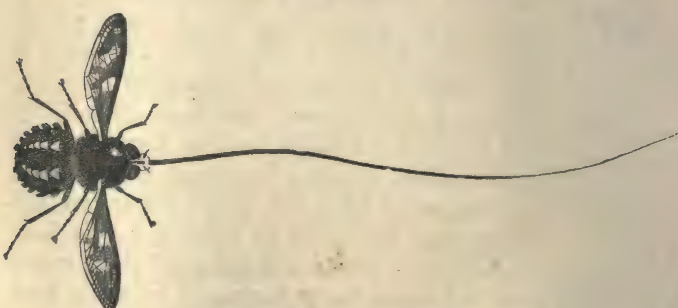


FIG. 321.—NEMESTRINA LONGIROSTRIS.

whose number varies from two to six, their analogues amongst the gnawing insects being the mandibles, the maxillæ, and the

tongue. Sometimes this proboscis acquires an enormous length (Fig. 321); sometimes on the contrary it is hardly visible.—Lastly, among the Butterflies, which are also supported on liquid substances, but which find them at the bottom of the flowers, and therefore have no occasion for instruments to procure them, there exist no *setæ* performing the functions of lancets, as among the preceding; and the mouth is furnished with a long tubular trunk, coiled into a spiral, and composed of two slender filaments, each channelled on its internal edge, so that a tube is formed by the adhesion of the two; these are nothing else than the maxillæ very greatly lengthened and modified in their form. At the base of this tube is seen a small membranous piece, which is the representative of the labrum; and on each side, a small tubercle, the only vestige of the mandibles. We also perceive the rudiments of the maxillary palpi; and behind is found a small triangular labium, having two very large labial palpi, composed of three joints, and nearly always clothed with scales.

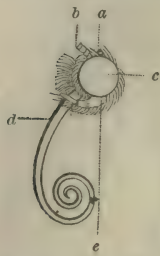


FIG. 322.—TRUNK OF A BUTTERFLY; *a*, head; *b*, base of antennæ; *c*, eye; *d*, trunk; *e*, palpi.

FIG. 323.—MORPHO HELENOR.

617. The alimentary canal generally presents a very complicated structure: sometimes it is straight, and has very nearly the same diameter throughout its entire length; but usually it is more or less convoluted, and has several successive enlargements, and contractions. We may distinguish in it (Fig. 324), a pharynx (*a*), an œsophagus (*b*), a first stomach or crop (*c*), a second stomach or gizzard (*d*), of which the walls are muscular and often armed with horny pieces fitted to triturate the food; a third or true digestive stomach (*e*), whose texture is soft and delicate; a small intestine (*f*), a cœcum, and a rectum (*g*). As

we see amongst the higher animals a connection between the nature of the food and the development which this canal acquires, so among the Carnivorous Insects it is generally very short; whilst among Insects which are supported on Vegetable substances, it is usually very long. The food which enters it, is at first moistened with the saliva; the apparatus which secretes this liquid consists of a certain number of floating tubes, terminated sometimes by small follicles or sacs, and communicating with the pharynx by their excretory canals. A multitude of *villi*, with which the digestive or chylific stomach is generally furnished, appear to serve for the secretion of a gastric juice; and it is also into this cavity, that the bile is poured. There does not exist any liver, properly speaking, among Insects; but this organ is replaced by long and delicate tubes (*h*), which float in the interior of the abdomen, and open high up in the chylific stomach. (Similar vessels, opening lower down, take the place also of the urinary glands; for uric acid has been found to be secreted in them.) By one of their extremities, the biliary vessels always open into the chylific stomach; and the other extremity is sometimes free, but sometimes fixed to the intestine, either near the first opening

324.—DIGESTIVE APPARATUS OF BEETLE; *a*, pharynx; *b*, œsophagus; *c*, crop; *d*, gizzard; *e*, chylific stomach; *f*, small intestine; *g*, rectum; *h*, biliary vessels.

or close to the rectum. Lastly we find, towards the extremity of the intestinal canal, other secreting organs, that serve to elaborate particular liquids (such as the poison of the Bee's sting), which several Insects can throw out from the extremity of their abdomen, when they are irritated.

618. It would appear to be by simple absorption, that the chyle traverses the walls of the digestive tube and mixes with the Blood. This liquid is watery and colourless; it is not everywhere inclosed in vessels, but spreads itself out into the interstices, which exist between distinct organs, or which present themselves in the substance of their tissue. Insects are destitute of a regular circulation. We can clearly see very rapid currents in certain parts of the body; but the nourishing liquid does not perform a circle in such a way as to return constantly to the point of its departure. There really exist amongst these animals only vestiges of a circulating apparatus.

Fig. 325.—Circulation in Insects.

We see near the dorsal surface of the body a longitudinal tube (*a*, Fig. 325), which performs alternate movements of contraction and dilatation, analogous to those of the heart among the higher animals. The nourishing liquid penetrates into it by lateral openings, furnished with valves to prevent its reflux; and

being propelled forwards by the successive contractions of its different chambers, it passes out in front by a series of canals, of which some convey it to the head, whilst others pass sideways and backwards (*b*), for the supply of the body with its appendages, the legs and wings. On returning from these parts, it re-enters the dorsal vessel, partly at its posterior extremity, and partly by the lateral orifices already mentioned.

619. It will be observed that, in this course, there is no special conveyance of the nutritious fluid, when rendered venous

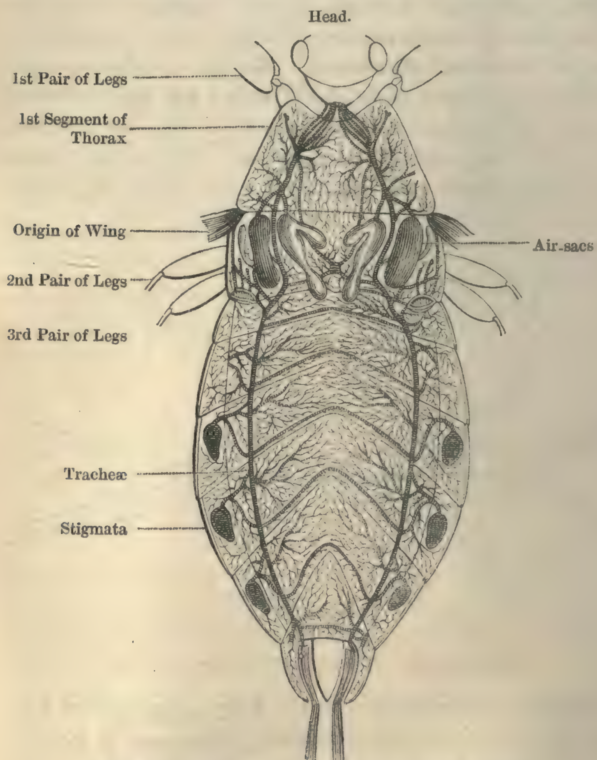


FIG. 326.—RESPIRATORY APPARATUS OF INSECT (NEPA).

in its character by circulating through the tissues, to a particular

organ for its aëration. If the Respiration of Insects were effected in the usual manner, by means of lungs, or at the external surface of the body, it would have been consequently extremely incomplete; but the disadvantage which would appear to be the necessary result of this great imperfection in a function so important as the Circulation, does not really exist. Nature has made up the deficiency in the transmission of the blood, by conducting the air itself into all the parts of the body, by the aid of a multitude of canals, which communicate with the exterior, and which ramify minutely in the substance of the organs. These air-conveying tubes, known, as we have already said, under the name of *tracheæ*, present a very complicated structure: we can usually distinguish in them three coverings, of which the middle one is composed of a cartilaginous filament, rolled in a spiral, like an elastic spring. Sometimes they are simple; but at other times they have a certain number of large dilatations, in the form of soft vesicles, which act as reservoirs of air. The openings by which the air penetrates into the tracheæ are called *stigmata* or *spiracles;* they are generally simple slits, like button-holes; but sometimes they have two valves, which open and shut like the leaves of a folding-door; and they are frequently furnished with a kind of sieve or grating, to prevent particles of dust, &c., being drawn inwards by the air. We usually see one pair upon the lateral and upper part of each segment; but they are often wanting on the two last segments of the thorax. The means by which the air is renewed in the interior of this respiratory apparatus, appears to consist generally only of the movements of contraction and dilatation of the abdomen. As we have already said, Respiration is very active amongst these animals; they consume a considerable quantity of air in comparison with their size, and they quickly die when they are deprived of oxygen; but when they are in this state of apparent death, they may remain in it a very long time, without losing the power of being restored to life.

FIG. 327.—AIR-TUBE OF INSECT.

620. The greater number of Insects produce but very little

heat; but some of these animals, in certain circumstances, give out a quantity sufficiently considerable to raise their temperature perceptibly. This is the case with Bees, when they are disturbed in their hives; and it is noticed that their Respiration then becomes very active. (See ANIMAL PHYSIOLOGY, §§ 410, 411.)

621. Another most remarkable phenomenon, of which the cause is not fully known, is the production of *light;* which is observed amongst some Insects. Of this the *Lampyris*, or Glow-worm, is an example, which is well known to almost every one who frequents our fields. The male has wings and is not luminous; but the female, which is destitute of them, and which is often found on banks and hedges during the summer evenings, sheds a phosphorescent light that is often very brilliant. In another species of Lampyris which inhabits Italy, the individuals of both sexes are at the same time winged and luminous; but this singular property is especially remarkable among certain Fire-flies, which live in the warm regions of America, and which produce, when flying in the darkness, a natural illumination of the most brilliant effect; they are often placed by women in their hair as ornaments; and we are told that the Indians use them to light themselves, when they travel by night. Among our Glow-worms, the light proceeds from certain spots situated upon the upper part of the two or three last rings of the abdomen; whilst among the Fire-flies, it comes from analogous spots placed upon the prothorax or corslet. It appears that the insect can vary at pleasure the intensity of this phosphoric light; and that it continues during a certain time, when the animal is placed in a gas unfit for respiration, or even in a vacuum; but that it is extinguished in cold water.

FIG. 328.—MALE AND FEMALE GLOW-WORM.

622. The sexes are distinct amongst these animals, and there often exist very great differences between the male and female;

the common Glow-worm has already afforded us an example of this (Fig. 328). Nearly all Insects lay eggs; some of them are, however, viviparous. There often exists at the extremity of the abdomen of the female, a dart, a saw, or some other organ, fitted to make holes for the reception of the eggs; and by an admirable instinct, the mother always lays them in a place, where her young will find near them the food which they will require; and yet, in the greater number of cases, this food is not the same as she would seek for herself. During the early period of their lives, insects change their skin several times, and nearly always display some very singular phenomena, of which we have already seen an example amongst the Batrachian Reptiles. The greater number of them, at the time of their coming forth from the egg, neither resemble their parents, nor have the form which they will themselves acquire at a later period; and before arriving at a perfect state, they undergo changes so considerable, that we cannot better designate them than under the name of *metamorphoses*.

623. Insects, in general, pass through three very distinct states, known under the names of the *larva state*, the *chrysalis state*, and the *imago* or *perfect state;* but the changes which take place, are not always equally great; sometimes these changes render the animal perfectly different, at other times they only consist in the development of wings; and these various degrees of transformation are known under the names of *complete*, and of *incomplete*, *metamorphosis*.

624. The insects which undergo a *complete metamorphosis*, are always more or less vermiform (or worm-like), when they come from the egg, and when they are in a *larva* state; their body is long, almost entirely soft, and divided into moveable rings, of which the regular number is thirteen. Sometimes they are completely destitute of feet; at other times they are provided with a variable number of these organs; but the conformation of these is not at all analogous to that of the same parts in the adult animal. They have, nearly always, simple eyes, but they are sometimes entirely destitute of them; their mouth is usually fur-

nished with mandibles and jaws, whatever may be the form that it will afterwards assume; and we often see the first of these organs serving for locomotion, as well as for seizing the food.

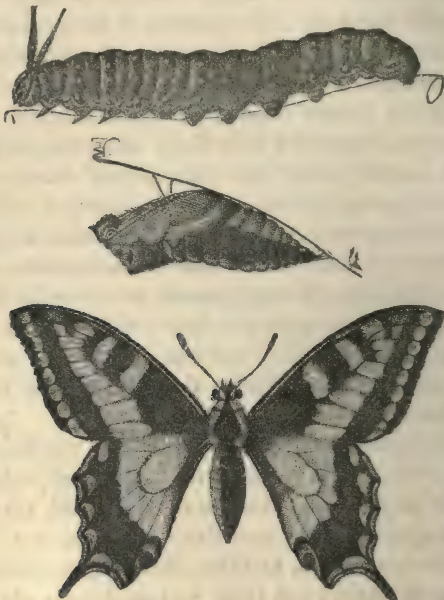


FIG. 329.—LARVA, PUPA, AND IMAGO OF PAPILIO MACHAON.

These Larvæ also differ in their form, and are sometimes known under the name of *Caterpillars*, sometimes under that of *Worms*.—After having remained in this state for a longer or shorter time, and having experienced several changes of skin, the wings begin to be formed beneath the skin, and the animal passes into the state of *chrysalis*. During the whole length of this second period of their existence, these singular animals cease to take any food, and remain motionless. Sometimes the skin from which they have last freed themselves, dries up, and forms a kind of oval case, in the interior of which they remain shut up; sometimes they are only

covered by a thin pellicle, which lies over the external organs, follows all their inequalities of surface, and causes the insect to appear as if closely wrapped in bandages.

625. Before undergoing this metamorphosis, the Larva prepares a defence for itself; and shuts itself up in a case, which it makes with *silk*, secreted by salivary glands, and drawn out by the aid of *spinnerets*, hollowed in the lips. In other instances, it suspends itself by means of threads, or conceals itself in some hollow. It is, however, whilst the insect is in this state of apparent repose, that active operations are going on within the body, of which the result is the complete development of the entire organisation. Its interior parts become soft, and by degrees assume the shape that they will preserve; the different organs, with which the adult animal ought to be provided, are developed under the envelope which conceals them; and when this evolution is finished, it frees itself from this species of mask; spreads its wings, which are not long in acquiring firmness, and becomes a *perfect insect* or *Imago*.

626. As an example of this complete metamorphosis, we cannot make a better selection, than by taking the *Bombyx Mori;* for this insect in its larva state possesses for us an immense interest; it is the *silkworm*, the rearing of which contributes so powerfully to the agricultural prosperity of the southern countries of Europe, and the product of which gives origin to so much industry and wealth. This insect came originally from the northern provinces of China, and was not introduced into Europe until the sixth century. The Greek Missionaries brought some of its eggs to Constantinople in the

FIG. 330.—SILKWORM.

reign of Justinian, and, at the period of the first crusades, its cultivation was spread into Sicily and Italy; but it was not until the time of Henry IV. that this branch of agricultural industry acquired any importance in the southern provinces of France, of which it now forms one of the chief sources of wealth.

627. The eggs of the Silkworm, when dry, have a gray-ash colour; and with some care they may be preserved thus during a very long time without injury. In order that the work of incubation may commence, and that the larvæ may be hatched, the eggs must be exposed for some time to a temperature of at least 60° Fahr. After having experienced an increasing heat for eight or ten days, they will become whiter; and soon afterwards the larvæ will begin to come forth. These little animals, at the time of their birth, are only about a line and a quarter in length. Their body is long, cylindrical, annular, smooth, and commonly of a grayish colour; at its anterior extremity we distinguish a head, formed by two hard and scaly tubercles, upon which are seen some black points, which are the eyes; the mouth occupies the anterior part of this head, and is armed with strong jaws; the three succeeding rings have each a pair of small scaly feet, and represent the thorax; the abdomen is very much developed, and has no members upon its two first segments, but is furnished at the posterior end with five pair of fleshy tubercles, which resemble stumps, and which serve as so many feet.

628. In the south of France, these worms are called *magnans;* and the name of *Magnanerie* is given to the establishments in which they are reared. The first care that they require after their birth, is to separate them from their shells, and to place them upon frames, on which they find the food adapted for their support. For this purpose it is usual to cover the eggs with a sheet of paper, perforated with holes, through which the worms creep to get at the mulberry leaves placed above; and when they are collected upon the boughs which are covered with these leaves, they are carried away upon the frames prepared for their habitation. The food of the Silkworm consists of Mulberry leaves; and consequently it is on the cultivation of this tree, that the capability of rearing these insects depends. The White

Mulberry is the species the most generally employed for this purpose. It is a tree which grows to the height of fourteen or fifteen feet; it flourishes very well in all soils, and it is cultivated with success even in the north of Europe; but it never grows wild anywhere. The Mulberry came originally from China. Two Greek monks introduced it into Europe towards the middle of the sixth century, at the same time with the Silkworm. Its cultivation was soon spread in the Peloponnesus, and gave to this part of Greece its modern name of *Morea*. Thence the Mulberries and the Silkworms were conveyed into Sicily under the direction of King Roger, and acquired a rapid extension in Calabria. Some French gentlemen who had accompanied Charles VIII. into Italy during the war of 1494, having known all the advantages which that country derived from this branch of agriculture, wished to bestow the same upon their own country; and brought some Mulberry trees from Naples, which they planted in Provence and Dauphiné. About thirty years since, the first of these trees planted in France was still to be seen at Allan, near Montélimart. At present the Mulberry trees cover a large part of the south of France; they are even cultivated in the north; and the success of some recent attempts appears to show, that they might be profitably cultivated in England.

629. Silkworms remain in the larva state for about thirty-four days; and during this time they change their skins four times. The time comprised between these successive changes, constitutes that which the cultivators call the different ages of these little animals. At the approach of each change they become dull and cease eating; but after having cast off the skin, their hunger is increased. The quantity of food which they consume rapidly increases. It is computed that for the larvæ proceeding from an ounce of eggs, there must be generally about seven pounds of leaves during the first age, which lasts five days; twenty-one pounds during the second period, which only continues four days; seventy pounds during the third period, which continues seven days; two hundred and ten pounds during the fourth age, whose length is the same as that of the third age;

and twelve or thirteen hundred pounds during the fifth period. It is on the sixth day of the last age, that the greatest voracity shows itself. The worms then devour two or three hundred pounds of leaves, and when eating make a noise which resembles that of a heavy shower. On the tenth day they cease eating, and prepare themselves to undergo their first metamorphosis. We then see them endeavouring to climb upon the branches of small bundles of twigs, which have been carefully placed above the frames on which they have until then remained. Their body becomes soft, and a thread of silk comes out of their mouth, which they draw after them. They very soon fix themselves, and throw around them a multitude of threads of extreme fineness; and, suspended in the middle of this net-work, spin their Cocoon, which they form by continually turning themselves round in different directions—thus twisting round their body the thread which comes out from the spinneret, with which the lip is perforated. The silk, thus formed, is produced in glands, which have much analogy with the salivary glands of other animals; and the matter of which it is composed is soft and glutinous at the time of its first appearance, but soon becomes hardened by the air. The result of the different twistings of this single thread, is to cause the different threads to adhere together, and to form an envelope, whose tissue is firm and shape oval. The colour of the silk varies; sometimes it is yellow, sometimes of a brilliant white, according to the variety of the worm which has produced it; and the length of each thread often exceeds 1100 feet, but varies much, as does also the weight of the cocoons. The worms proceeding from an ounce of eggs may produce as much as 130 lbs. of silk; but such an amount is rare; and from 70 to 80 lbs. is the usual product.

630. In general, three days and a half or four days are sufficient for the larva to finish its Cocoon; and if we then open this envelope, we see that the animal no longer presents the same appearance as before its seclusion. It has become of a brownish colour, its skin resembles old leather, and its shape is oval, a little pointed at its posterior extremity. We no longer distinguish a head or jaws; but the posterior extremity is formed by

two moveable rings, whilst in front we see an oblique band, representing the future wings of the perfect animal. The time during which the Bombyx remains thus shut up in a Chrysalis

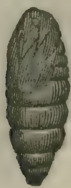


FIG. 331.—CHRYSALIS OF THE SILKWORM.

FIG. 332.—SILKWORM MOTH.

state, varies according to the temperature. If the heat is from 60 to 65 degrees, they come out of it in a perfect state on the eighteenth or twentieth day. In order to open the Cocoon, they moisten it at one extremity with a particular liquid, which they throw up from the stomach; and then they violently strike their head against the part thus softened. When the Bombyx has thus finished its metamorphosis, it presents itself under the form of a Moth, with whitish wings; its mouth is no longer furnished with jaws, as in its early state, but is prolonged into a rounded spiral trunk; its legs are slender and lengthened, and its internal conformation differs as much from that of the Larva, as its external form. Almost immediately after this second birth, the Moths seek each other for the purpose of reproduction; and the females subsequently deposit their eggs, of which the number sometimes amounts to more than five hundred for each of these insects; and at last, after having lived in a perfect state for ten or twenty days, during which time they take no food, they die.

631. Among Bees we meet with still greater changes; since in their Larva state they are completely destitute of legs, and resemble small worms. It is the same with Flies, Gnats, and a great number of other insects; thus the vermiform animals which swarm in putrid carrion, and which are known under the name of Maggots, are nothing else than the larvæ of the Meat-fly. The Gnats or Musquitoes, which fly in such large swarms, and

which render themselves so unpleasant to Man by their venomous punctures, live in the water during their larva state. They are then vermiform, destitute of limbs, and have the abdomen terminated by bristles and some appendages arranged in a radiated form (Fig. 333); and from their last ring arises a long tube, by the aid of which the animal draws in from the atmosphere the air which it requires. To breathe by this means, it suspends itself as it were from the surface of the water, with its head downwards; and we see it performing this movement at short intervals. The Chrysalis continues to live in the water, and to move about there; but instead of breathing like the larvæ, it draws in the air which it requires by means of two pipes, placed upon the thorax. It floats on the surface of the liquid; and after having completed its metamorphosis, the perfect insect uses the skin of the chrysalis as a boat, until its long legs and wings have gained sufficient strength to enable it to move on the surface of the water, or to fly away; but if its body happens to be submerged, as often occurs when the wind upsets these frail barks, it is infallibly drowned.

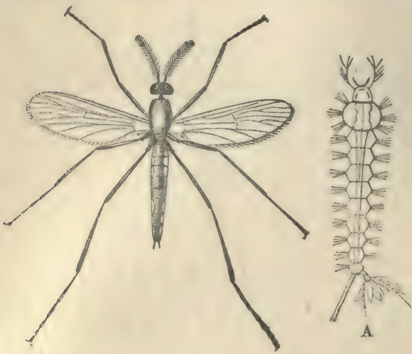


FIG. 333.—GNAT AND LARVA.

632. The Insects with incomplete metamorphosis also pass through the larva and chrysalis state, before arriving at the perfect state; but here the larva only differs from the perfect insect by the absence of wings; and the state of the chrysalis is only characterised by the gradual development of the wings, which, at first folded back and concealed under the skin, then become free; but only acquire their full development at the period of the last change. We may mention, as examples of

insects showing this kind of metamorphosis, the Grasshopper and the Ephemeræ or Day-flies. These last display a remarkable peculiarity; since in general, insects change the skin for the last time, when they pass from the Chrysalis to the perfect state; whilst the Ephemera experiences one more change, before arriving at its complete form, in which it only lives for the space of a few hours. The larva of the Ephemera lives in the water, and differs very little from the adult, except in the shortness of its limbs, the absence of wings, and by the row of leaf-like appendages which it bears on each side of its abdomen, and which it uses as organs of respiration and of motion in the water. The chrysalis only differs from the larva, by the presence of cases inclosing the wings. At the time when these organs should be developed, the insect comes out of the water; and after having fluttered about during some minutes, it takes its place upon an elevated object, and there performs some violent movements, by means of which it casts away its enveloping membrane; it is then only that its limbs attain their full length, and that the body acquires the colours which it will preserve.

Fig. 334.—Ephemera Vulgata: Larva, Pupa, and Imago.

633. Some Insects, although undergoing considerable changes at an early period, do not pass through the complete series of transformations of which we have first spoken; they appear to stop short in their development, never possessing any wings. The Fleas are thus circumstanced. When they come forth from the egg, they are destitute of feet, and have the form of small worms of a whitish colour. These larvæ are very active, and roll themselves in a circle or a spiral. They soon become of a reddish hue; and after having lived in this condition during

twelve days, they shut themselves up in a small silky shell, of extreme delicacy, and are there transformed into a chrysalis; at the end of about twelve days of seclusion, if the weather is warm, they come out of their envelope in a perfect state.

634. Again, there are some Insects which do not pass through any metamorphosis, and which are born with all the organs with which they will ever be provided; but it is only among *Apterous*, or wingless, Insects, that this mode of development exists. The Podura, which has been already referred to, and the Louse, are of this kind.

635. The class of Insects, which (as we have seen) is so remarkable for its organisation, is still more so in regard to the habits of the animals composing it, and the admirable instincts with which Nature has endowed a great number of them. The stratagems which they employ to procure themselves food, or to escape from their enemies, and the industry which they display in their labours, astonish all those who are witnesses of it; and when we see them unite themselves into numerous societies, to make up for their individual weakness, helping each other by dividing the labour necessary for the prosperity of the community, providing for their future wants, and often even regulating their actions according to the accidental circumstances in which they find themselves placed, we are confounded at encountering amongst beings so small, and in appearance so imperfect, instincts so varied and so powerful, and intellectual combinations which so much resemble those of the reasoning powers. This subject will be more fully treated of in the latter part of the present volume. At present we must confine ourselves to a sketch of the classification of this group; which, on account of the immense number of forms included in it, must be more slight than that which has been given of the preceding classes.

636. The subdivision of the Class into Orders is founded chiefly upon the structure of the Mouth, the conformation of the Wings, and the nature of the Metamorphosis. Neither of these characters must be trusted to singly; since within the limits of one group, we find considerable variation. Thus in almost every order, we meet with *apterous* or *wingless* insects; an example of

which we have already seen in the Glow-worm. Sometimes, as in that instance, the deficiency of wings is confined to one of the sexes—usually the female; whilst in other cases, both sexes are destitute of these organs. Nevertheless there is a group, consisting of three small orders, in which the want of wings is the rule and not the exception; and the insects brought together in these, are associated together on account of their resemblance to each other in general structure;—whilst, on the other hand, the wingless insects first alluded to are left among the orders in which they are placed, on account of their correspondence with other insects of those orders in the structure of the mouth, the nature of the metamorphosis, &c.

637. We may divide the Class into two Sub-classes; the members of the first of which (A) always undergo some degree of metamorphosis, and are usually possessed of wings in the perfect state; whilst those of the second (B) undergo no metamorphosis, and never become possessed of wings.—From the first sub-class may be separated one order, in which there are no wings; and there then remain *eight* principal orders, which are classed according to the structure of the mouth and wings.

Sub-class A.

Division *a.*—Winged insects undergoing metamorphosis.

Order I. Coleoptera (*Beetles*). In these the mouth is formed for mastication; the anterior wings are converted into hard *elytra*, or wing-cases; the posterior wings are folded transversely (or cross-wise) during repose; and the metamorphosis is complete.

Order II. Orthoptera (*Grasshopper*, *Locust*, *&c.*). In these also the mouth is formed for mastication; the anterior pair of wings is composed of a substance more resembling parchment; the posterior pair, when in repose, is folded longitudinally (or lengthwise) in the manner of a fan (Fig. 369); and the metamorphosis is incomplete.

Order III. Neuroptera (*Dragon-fly*, *May-fly*). In these, too, the mouth is formed for mastication; but the anterior pair of wings, like the posterior, is membranous; and the nerves of

the wings form a close reticulation or network by their interlacement. The degree of metamorphosis is variable.

Order IV. Hymenoptera (*Bee, Wasp, Saw-fly*). In these, the mouth is still furnished, as in the preceding, with prehensile mandibles, but the other parts are so formed as to be rather fitted for suction than for mastication; the wings are all membranous, but the nerves do not form such a minute reticulation as in the preceding order; the metamorphosis is always complete.

The four preceding orders, in which *mandibles* are always distinctly present, form the group of Mandibulata; the four succeeding, in which the mandibles are wanting or are completely changed in form, and in which the other parts are adapted for suction, being converted into a more or less complete *haustellium* or sucking-tube, are termed Haustellata.

Order V. Homoptera (*Cicada, Lantern-fly*). In this order, the four wings are of the same consistence, and are rather firmer than usual, being often somewhat parchmenty in texture; when folded, they incline at an angle, like the roof of a house.

Order VI. Heteroptera (*Bugs, Boat-flies*). The consistence of the two pairs of wings is here different, the anterior pair of wings being of a horny or parchmenty consistence (though generally tipped with membrane), whilst the posterior are simply membranous; when folded, they are horizontal, or but slightly inclined, and sometimes lap over each other.

Order VII. Lepidoptera (*Butterflies and Moths*). These have the mouth furnished with a long trunk, coiled in a spiral when not in use; the wings are all membranous, and are covered with minute scales, having the appearance of fine dust, but arranged with the most perfect regularity; the metamorphosis is complete.

Order VIII. Diptera (*Gnats, Flies, &c.*) In these there are but two wings; the mouth is furnished with a sucking-tube; and the metamorphosis is complete, or nearly so.

Division *b*. Insects undergoing metamorphosis, but destitute of wings. This division includes but a single order.

Order IX. Aphaniptera (*Flea, &c.*) In this group, also, the mouth is formed for suction; and the insects composing it are parasitic, living upon the juices of other animals.

Sub-Class B.

The small remaining section, consisting of Insects which undergo no metamorphosis, and are destitute of wings, includes two orders.

Order X. Anoploura (*Louse*). These are distinguished from the succeeding, by the absence of appendages to the abdomen.

Order XI. Thysanoura (*Spring-tails, &c.*) In these the abdomen is furnished with false legs, or appendages, adapted for leaping.

Besides these principal groups, there are some small intermediate orders, by which the former are connected. These are not admitted, however, by all Entomologists. Thus the *Earwig* tribe, which combines, in some degree, the characters of the Coleoptera and Orthoptera, is raised by many to the rank of a distinct order—Dermaptera, which leads from the first to the second order. Again, a separate order—Trichoptera, has been formed to include the *Caddice-flies*, which are intermediate between the Lepidoptera and Neuroptera. And, lastly, there is a small order—Strepsiptera, or Rhipiptera, which includes a small group termed *Wasp-flies*, intermediate, in several respects, between the Hymenoptera and Diptera, but differing from both in so many particulars, as apparently to require being arranged by themselves.

Order I.—COLEOPTERA, OR BEETLES.

638. The insects composing this Order, all of which are known under the common name of *Beetles*, are the most numerous and best known of the whole class. The singular forms and brilliant colours exhibited by many of the species, the size of their bodies, the solid texture of their integuments, which facilitates their preservation, and the nature of their habits, which makes their capture more easy, have combined to render them an object of peculiar attention to Entomologists, many of whom have devoted themselves to this order exclusively. It is probable that from 30,000 to 40,000 species of Beetles alone now exist in

the cabinets of collectors; and we may safely affirm, that at least as many more yet remain to be discovered.

639. The conversion of the first pair of wings into *elytra*, or hard wing-cases, and the complete inclosure of the second pair by these, when the insect is at rest, constitute, as we have seen, the distinguishing features of the Order. The elytra, when expanded, are of little or no use in flight, generally remaining nearly motionless; when closed, they meet along the back in a straight line, which is called the *suture*. The structure of the mouth, in this order, has been already described. The head is provided with two antennæ, which vary in form, but which have usually eleven joints; the form of these often differs considerably in the two sexes. The eyes are large and protuberant, especially in the carnivorous species, and in those, the slowness of whose habits makes them need quick powers of sight, for the purpose of avoiding their enemies. Of the three segments of the thorax, the anterior one (commonly termed the corslet) greatly surpasses the two others in size; being so much developed at their expense, as almost to constitute the thorax by itself. The two latter segments are firmly united to each other, and to the commencement of the abdomen; and the chief movement of the parts of the trunk upon one another, is between the first and second segments of the thorax; the latter being prolonged forwards into a sort of footstalk, which is received into a cavity in the former, and thus serves as a kind of pivot for its movements. The abdomen usually consists of only six or seven segments; the remainder of the nine, which properly form this part, being consolidated in the last.

640. Although the characters already mentioned are applicable to by far the greater number of insects included in this Order, nearly all of them are subject to exceptions. Thus, there are many species, in which the organs of flight seem altogether wanting, in one sex, at least, as in the female Glow-worm; even here, however, the rudiments of elytra will be found. In other instances, the elytra are fully developed, so as to cover the upper surface of the body; but adhere together along the suture, so as to prevent the expansion of the wings, which are, consequently,

never developed; this is the case in the *Blaps* (Fig. 349). In other cases, again, the elytra, instead of simply meeting along the suture, fold over each other; in other instances, they do not meet at all; and there are some species in which the wings are folded, not *transversely*, but *longitudinally*, as in the next order. It is well for the Student to be aware that such exceptions exist in this, as in every other large natural group; however definite its characters may generally be. In none of these instances, is there an exception as to more than one or two of the characters in question; the remainder conform to the usual type.

641. The Metamorphosis in this Order is invariably *complete;* and it is thus distinguished from all that approach it in the structure of its mouth, or in the character of the wings. The *larvæ* are worm-like in their aspect; the head is usually horny, the rest of the body soft. There is generally a pair of short jointed legs attached to each of the first three segments, bearing some resemblance to those of the perfect insect. Those which possess legs are usually active in their habits; but there are others which, leading a retired life, and being born in the midst of their food (such as the Nut Weevil), are destitute of members. The larvæ of the carnivorous species have in general the most robust legs; and in some of the herbivorous species these are replaced by fleshy tubercles, or *pro-legs*. A pair of these generally exists on the last segment

FIG. 335.—LARVA, PUPA, AND PERFECT STATES OF CETONIA AURATA, OR ROSE-BEETLE.

of the abdomen. Previously to undergoing its change, the larva often forms a case for itself, of bits of earth, or chips of wood, united by silken threads, or by gluey matter. The *pupa*, or chrysalis, is inactive, sometimes even for years, and takes no nourishment; but the form of the future Beetle is plainly perceived, the different parts being encased in distinct sheaths. (Fig. 335).

642. There is much difficulty in forming a simple natural classification of this immense tribe, on account of the great number of distinct species which it includes, and their strong general resemblance to each other. Hence it is often necessary to resort to characters of great minuteness as the ground-work of the system; and it sometimes happens that, by the adoption of such a plan, tribes which are in reality closely allied in general structure, are placed in different groups, whilst others are brought together which are in many respects dissimilar. No better system, however, has yet been proposed than that of Latreille; who took as the basis of his classification the number of joints in the *tarsus* or last portion of the foot (§ 607). The four following sections are thus formed.

I. PENTAMERA (five-parted), in which the tarsi of all the feet are distinctly 5-jointed.

II. HETEROMERA (differently-parted), in which the tarsi of the first two pairs of feet are 5-jointed, and the two posterior 4-jointed.

III. TETRAMERA (four-parted), in which all the tarsi appear to be 4-jointed. (It has lately been observed, however, that the fifth joint exists in these, although it is very minute, and concealed in one of the others.)

IV. TRIMERA (three-parted), in which all the tarsi have three distinct joints. (A fourth of small size, however, is also present.)

Each of these sections contains several families; of which the most important will now be noticed.

643. Section I. PENTAMERA. The first family of this section consists of Beetles which are exclusively carnivorous; hunting after, and devouring, other insects; and being carnivorous

even in their larva state. These CARNIVORA are characterised by the possession of six palpi,—there being two to each of the maxillæ (Fig. 315),—and by the termination of the jaws in a sort of claw or hook. Some of them are *terrestrial*, and others *aquatic;* in the former, the legs are adapted only for running; in the latter, they are modified for swimming.—The terrestrial division of the family is composed of two very large tribes, the *Cicindelidæ* and the *Carabidæ*, characterised chiefly by the form and mode of attachment of the hook at the end of the jaws. The *Cicindelidæ* have the body usually of a dark or light-green colour, varied with shining metallic tints, and with white spots upon the elytra; they frequent dry situations exposed to the sun, run very quickly, fly off when they are approached, and alight again at a short distance. The larvæ burrow in the earth, forming a cylindrical hole of considerable depth; in the process of excavation they use their jaws and feet, and load the concave back of their heads with the grains of earth which they have detached; thus loaded, they ascend backwards, resting at intervals, and fixing themselves to the inner walls of their burrow by the assistance of two hooked tubercles on the back; when arrived at the orifice, they jerk off their load to a distance. Whilst lying in ambush, the flat plate of the head exactly stops the mouth of the hole, forming a flat surface with the surrounding soil. When their prey comes within their reach, they rush upon it with great ferocity, and seize it between their powerful jaws; and their voracity is even extended to larvæ of the same kind. They close the orifice of their burrow when they change their skin, or undergo their metamorphosis into the pupa state. There are several British species of this group; as well as a large number of brilliantly-coloured tropical species, of which many are apterous.

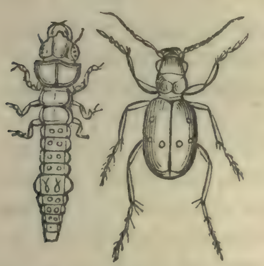


FIG. 336.—CICINDELA CAMPESTRIS, AND LARVA.

644. The tribe of *Carabidæ* is of very great extent; above

2000 species having been brought together by a single collector.

FIG. 337.—CARABUS.

Their bodies are of very firm consistence, whereby they are enabled to creep under stones and through fissures, and are also prevented from being injured by the insects they attack. They prowl about on the surface of the ground, under stones, &c., beneath the bark of trees, or the moss growing at their roots, in search of their insect prey, which consists chiefly of the herbivorous species of their own order. Some of them are nocturnal in their habits, feeding upon Cockchafers and other species of herbivorous beetles that fly abroad during the night. The habits of this tribe are not exclusively carnivorous, however, for some species, generally found in corn fields, are clearly ascertained to feed upon growing grain.—Many species of this tribe are provided with a very curious means of defence; being enabled to exhale a very fetid odour, and to discharge from the abdomen, to a considerable distance, an acrid fluid, capable of producing much irritation. In the *Brachinus* this fluid is so highly volatile, that, immediately on coming in contact with the air, it passes into a bluish vapour of very pungent scent, and makes a sort of explosion; hence the species possessed of this power have been termed *Bombardier* Beetles. The larger species are found only in tropical regions; but the small species represented in the accompanying figure, is a native of England. The Bombardier Beetles for the most part live in societies, especially in spring; and are found concealed under stones. Of the entire family, a considerable proportion are found in Britain and other temperate countries; but the largest and most brightly-coloured species are confined to warmer climates.

FIG. 338.—BOMBARDIER BEETLE.

645. The *aquatic* Carnivora form a tribe far less numerous than the terrestrial species; and are at once distinguished by the peculiar modification of the legs, which adapts them for swimming,

—these members being flattened, and fringed with bristles, so as to serve as oars. They live, during their larva and perfect states, in water; but they quit that element to undergo their metamorphoses, and to pass the time of their pupa condition. The larvæ have the body long and narrow, with a strong head armed with powerful mandibles; and they are of very active carnivorous habits. They breathe by organs adapted for aquatic respiration; but the perfect insects can only breathe air, and are obliged to come to the surface occasionally for that purpose.

Fig. 339.—Dytiscus Marginalis and Larva.

The *Dytiscus*, the principal genus of this tribe, is common in fresh and placid waters, such as lakes, pools, or ditches. Its larva feeds upon other aquatic larvæ, such as those of dragon-flies, gnats, &c.; and moves quickly through the water, by means of strokes with its expanded tail. The pupæ may be found buried in the adjoining banks. The Imago also is very voracious, feeding principally upon the juices of the animals it attacks, which are often much larger than itself; an individual has been kept in a large bottle of water for three years and a half, being fed once a week or oftener with a bit of raw beef, from which it extracted the blood, but being able to fast for a month at a time.—The other principal genus is the *Gyrinus* (Fig. 299), the common species of which are known under the name of "Whirligigs," from their peculiar motion. These may be met with, from the first fine days of spring until the end of autumn, on the surface of quiet waters, and even upon that of the sea, often assembled in great numbers, and appearing like brilliant points. They swim with great agility, often curveting in a circular direction,—whence their common name. Sometimes they remain stationary without the slightest motion; but no sooner are they approached, than they escape by darting under the surface of the water, and

swimming off with the greatest agility. The four hind-legs are used as oars, and the anterior pair for seizing the prey. When they dart beneath the surface, a bubble of air, like a silvery ball, remains attached to the hind part of the body.—Numerous species of both these genera are found in Britain.

646. The next family of the Pentamerous Beetles is that of BRACHELYTRA, distinguished, as the name imports, by the shortness of the *elytra;* these, which have only four palpi, contain but a single tribe, composed of the genus *Staphylinus* and its allies. These insects run and fly with equal agility; they are extremely voracious; but do not feed on living prey, deriving their nutriment from dead and decaying animal and vegetable matters. The majority live in the earth, amidst manure and putrescent substances; others are found among Fungi and rotten wood, and under stones; others, again, are only met with near water; and a few of the smallest are only found in flowers. The larvæ feed on the same substances, and in the same situations, as the perfect insects; and greatly resemble them in form. These Beetles,—of which one of the largest is frequently to be seen running about garden-walks, and is commonly known under the name of the Devil's Coach-horse,—turn up the end of the body when touched, bending it in all directions; and they possess the power of emitting a strong odour, which is in some instances extremely fetid, and which serves as a means of defence.

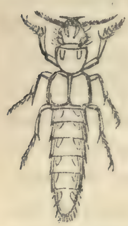


FIG. 340.—STAPHYLINUS ERYTHROPTERUS.

647. The next family, SERRICORNES, is distinguished by the toothed or serrated form of the antennæ. As in the preceding, there are only four palpi; but the elytra completely cover the body. Some of this family, having the body of solid consistence, and oval in form, have the head buried, as it were, in the thorax, which advances on its two sides, nearly as far as the mouth. In this manner is formed the *Buprestis*, distinguished for the splendour of its colours; many of its species having spots of golden hue upon an emerald ground; whilst in others, azure glitters upon the gold. The largest and most brilliant species

are found chiefly in tropical climates, which these insects appear especially formed to inhabit ; our native species, which are not above a quarter of an inch long, being observed to fly with the greatest activity in warm weather. They live among trees ; and, if an effort be made to seize them, they counterfeit death, and fall to the ground.—The Beetles belonging to the allied genus, *Elater*, are commonly called Skip-jacks ; for, when laid on their backs, being unable to raise themselves on account of the shortness of their legs, they spring perpendicularly in the air, so as to alight upon their feet. This is effected by first bending the head and anterior portion of the thorax towards the abdomen, and then violently straightening it, so as to give a backward stroke against the surface on which they are lying. The larva of one of the British species, known to the farmer as the Wire-worm, does much injury by devouring the roots of the corn. A species of Elater, inhabiting the West Indies and South America, is one of the most brilliant of the Fire-flies ; having two brightly-illuminated spots upon the front of the thorax, and a portion of the abdomen which is uncovered during flight being also very luminous.—Nearly allied to the Elaters is the *Lampyris* or Glow-worm tribe ; of which sufficient mention has been already made. —To the same very numerous family belong the genus *Ptinus* and its allies ; one species of which is well known under the name of Death-watch. These are insects of small size and slow movements ; many of them are destitute of wings ; and those which possess them seldom use them as means of escape. When touched, they counterfeit death by lowering the head, drawing in the antennæ, and contracting their feet ; and they remain in this position for some time. Their colours are always obscure, and but slightly variegated ; and they live in dark places near or upon the surface of the ground. Of the sub-genus, *Anobium*, many species inhabit the interior of our houses, where they do much injury in the larva state, by gnawing furniture,

FIG. 341.—ANOBIUM STRIATUM, NATURAL SIZE AND MAGNIFIED.

books, &c., which they pierce with little round holes, like those made by a drill. Other species feed upon flowers, wafers, preserved specimens of natural history, &c. The curious sound made by them—from which have arisen the superstitious ideas that gave origin to their common name,—has been elsewhere noticed (ANIM. PHYSIOL. § 677). The species is remarkable for the pertinacity with which it feigns death when alarmed; preferring, it is said, to suffer death under a slow fire, rather than give the least sign of life.

648. The succeeding family, that of CLAVICORNES, consists of those Pentamerous Beetles, whose antennæ end in a club-shaped enlargement. These are partly terrestrial, and partly aquatic. They feed for the most part on animal matter, at least in the larva state; but a large proportion of them prefer substances which are in a decaying or putrescent condition. One of the most interesting genera is the *Necrophorus* or *Burying Beetle;* so named from its habit of excavating the ground beneath the dead bodies of small quadrupeds, such as Mice or Moles; when they have interred the carcass, they deposit their eggs in it, and the larvæ, when hatched, feed upon the flesh.—Another genus, which includes a large number of species, is the *Dermestes;* of which the larvæ (whose bodies are hairy) are very voracious, feeding on the skins or carcasses of animals, often destroying collections of insects, and committing great ravages in fur-warehouses.

FIG. 342.—DERMESTES.

649. The PALPICORNES also possess antennæ with a club-like termination; but these are never longer, and are usually shorter, than one of the pairs of palpi. Nearly all of them are aquatic, and have their legs adapted for swimming, somewhat in the manner of those of the Dytiscus. The most remarkable genus is the *Hydrophilus*, of which one large species, an inch and a half long, oval, of a brown-black colour, and highly polished, is common in the ponds and ditches of this country. It swims and flies well, but walks badly. The eggs are laid in a sort of cocoon, spun by the female, and coated with a gummy matter that is

impervious to the water on which it floats. The larvæ, which have a worm-like body, with six feet, and with sharp mandibles arming the head, are very voracious; feeding upon Tadpoles and the young fry in fish-ponds, and upon small fresh-water Mollusca.

Fig. 343.
Hydrophilus.

650. The last family of the Pentamerous section, the Lamellicornes, is of very great extent, as well as one of the most striking of the whole Beetle tribe, in regard to the size of the body, and the variety in the form of the head and thorax in the different sexes; and also, moreover, in those species which in their perfect state live upon fresh vegetable substances, in respect to the brilliancy of the metallic colours with which they are ornamented. But the majority of other species, which subsist on decomposing vegetable matter, are of an uniform brown or black colour; although some are not inferior in brilliancy to the preceding. All have wings; and they crawl but slowly along the ground. None of them are aquatic. Their food consists of dung, manure, tan, and particularly, in some species, of the roots of vegetables; whence these insects, in their larva state especially (this being always the period of greatest voracity), often occasion great loss to the cultivator.—This family receives its name from the peculiar conformation of the antennæ, which terminate in a mass formed of the last three joints; these are flattened into plates or lamellæ, and are sometimes arranged like a fan or the leaves of a book, sometimes in the manner of a comb, and sometimes inclosing one another. The family is divided into two principal sections, the *Scarabœi* and the *Lucani.*

651. Of the *Scarabœi,* one subdivision, including the sacred Beetle of the Egyptians (Fig. 344), feed principally upon the excrements of various animals; and they inclose their eggs in balls of the same (whence they have been called Pilularii), which they roll along with their hind feet, several often being in company, until they reach the hole in which these are to be deposited. Of these we have a characteristic example among British species, in the *Geotrupes stercorarius,* the

common Dor or Shard-borne Beetle; which is one of the commonest of all Beetles in this country. One of the most

FIG. 344.—ATEUCHUS (SCARABÆUS) ÆGYPTIORUM.

FIG. 345.—GEOTRUPES STERCORARIUS.

remarkable amongst foreign species is the *Dynastes Hercules*, a native of Brazil, which attains the length of 5 inches, and of which the male possesses an enormous horn projecting from the head, which is opposed by a corresponding protuberance from the thorax. To this group also belongs the *Melolontha vulgaris* or common Cockchafer; which is most destructive to vegetation in both its larva and perfect conditions, feeding on the roots in the one case, and on the leaves and young shoots in the other. The larvæ live for three or four years beneath the ground; becoming lethargic in winter, but actively voracious in summer. Their excessive multiplication is usually prevented by birds; but if these be kept away, they increase very rapidly, and become a complete pest to the cultivator. The perfect insects sometimes make their appearance in such swarms, as to

FIG. 346.—DYNASTES HERCULES.

FIG. 347.—LARVA OF COCKCHAFER.

devastate an entire forest. To this group also belongs the *Cetonia aurata* or Rose-beetle, a very common British insect, of which a figure has been already given (Fig. 335) ; it is about an inch long, of a shining-green colour above, coppery-red beneath, with white marks on the elytra. In its larva state, it frequents rotten timber and wood, and is often met with underground in ants' nests, where it would seem to feed upon the bits of wood of which they are composed ; from this circumstance it is sometimes called the "king of the ants." After remaining about three years in the larva state, it makes a sort of cocoon of chips of wood, glued together by an excretion of its own ; in this it passes the winter in the state of an inactive pupa, from which it emerges in the following summer in its perfect form. The Rose-beetle flies well, with a considerable humming noise, during the hottest part of the day ; and goes from flower to flower (not confining itself to Roses, but seeming to prefer them), sucking the honey from their interior, and sometimes devouring their nectaries.

652. The *Lucani*, or Stag-Beetles, derive their common name from the peculiar form of the mandibles, which are very large, curved, and toothed, like stags' horns (Fig. 316). The *Lucanus cervus*, a highly-characteristic species of the group, is one of the largest of British insects, the males being two inches or more in length. This species flies about in the evening, in the middle of summer, especially round the oaks, upon the wood of which the larva feeds ; remaining in that state for several years, before undergoing its final transformation. The accompanying figure represents the *Dorcus parallelipipedus*, or Small Stag-Beetle of this country ; which is far less striking than the larger species in regard to the development of its maxillæ. Some of the exotic species of this group are very large and splendidly coloured.

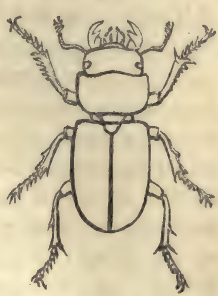


FIG. 348.—DORCUS PARALLELIPIPEDUS.

653. Section II. HETEROMERA. The Coleoptera of the Second section, characterised by possessing five joints in the tarsi of the two anterior

pairs of feet, and of only four in the posterior tarsi, entirely feed on vegetable substances; they are all terrestrial, and most of them frequent dark places.—In the first family, the MELASOMA or *black-bodied* Beetles, the body is usually of an ashy-brown or black colour; and the wings are for the most part absent, the elytra being united along the suture. They usually live in the ground, beneath stones, or in the sand—often also in low and dark parts of buildings, such as cellars, stables, &c. The insects of this tribe are very tenacious of life; individuals having been known to remain alive for six months without food, and pierced through with a pin. To this family belong the *Blaps mortisaga*, a beetle often found in dark and dirty places about houses; and the *Tenebrio molitor*, of which the larva, known under the name of the *meal-worm*, lives in corn and flour, whilst the perfect insect also frequents bake-houses, corn-mills, &c., where it may be often found in the eaves.

FIG. 349.—BLAPS MORTISAGA.

FIG. 350. TENEBRIO MOLITOR.

654. We may pass over the families of TAXICORNES and STENELYTRA, as presenting no points of special interest, to notice the TRACHELIDES (*necked*-beetles), so named from having the head, which is triangular or heart-shaped, carried on a kind of neck, which separates it from the thorax. The body is soft; and the elytra are flexible, and sometimes very soft. The majority of this group live in the perfect state upon different vegetables, devouring the leaves, or sucking the juices of the flowers.—Many of them, when seized, depress the head and contract the feet, as if they were dead. Their colours are often very brilliant. This is well seen in the *Cantharis vesicatoria*, commonly known

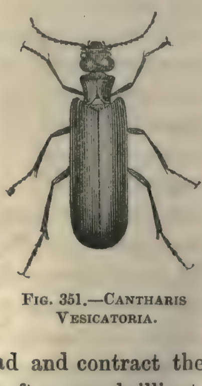


FIG. 351.—CANTHARIS VESICATORIA.

as the Blistering-fly, which is of a shining green metallic hue; this insect is most abundant in Spain, but appears about midsummer in France, and is found in great numbers on the ash and lilac, of which it consumes the leaves. Its larva lives in the earth, and feeds upon the roots of vegetables.

655. Section III. TETRAMERA. All the Beetles of this group, likewise,—consisting of those which have four joints in all the tarsi,—are vegetable-feeders. The perfect insect is found upon the flowers and leaves of plants; the larvæ are often produced in their interior; and, when thus hatched in the midst of their food, their legs are commonly very imperfect. Very often the true legs are almost entirely absent, and their place supplied by fleshy tubercles. The first family, that of RHYNCOPHORÆ, or the *Weevil* tribe, is distinguished by the prolongation of the anterior part of the head into a kind of muzzle (Fig. 352, D). The number of species in this family is very great; nearly four thousand have been already collected. Many of them are extremely destructive; especially the *Calandra granaria*, which commits great havoc in granaries, both in its larva and perfect states. The accompanying figure exhibits the history of the development of the *Balaninus nucum*, or Nut-Weevil, whose larva is so commonly found in nuts, filberts, &c. The egg is introduced by the parent when the nut is young and soft; and the wound made by it heals over. The larva, when it comes forth from the egg, feeds upon the kernel in which it is imbedded; and, when about to change its state, it bores through the shell, and escapes, leaving

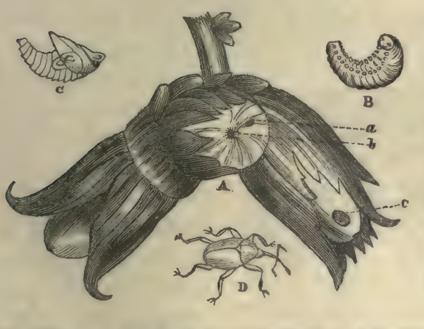


FIG. 352.—A, a branch of the filbert tree; *a*, a healed wound caused by the introduction of the egg of the nut-weevil; *b*, extremity of the nut; *c*, exit hole of the grub; B, the grub of the nut-weevil; C, the pupa of the same; D, the perfect insect (*Balaninus nucum*).

a small round orifice. To this tribe belongs one of the most splendid of all Beetles, the *Curculio imperialis*, well known as the Diamond-beetle, which is a native of South America, and very abundant in some parts of that country. There are small species belonging to our own island, however, which are scarcely less brilliant when magnified under a good light.

656. The second family of the Tetramerous Coleoptera has received the name of Xylophagi (or *wood-eaters*), on account of the peculiar habits of the Beetles composing it. They usually live in wood, which their larvæ pierce in every direction; and, when abundant in forests, especially those of pines

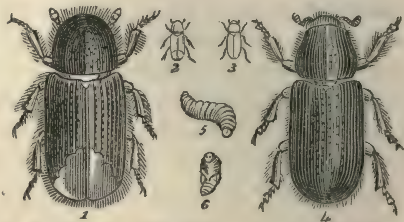


Fig. 353.—1, 2, Tomicus typographus; 3, 4, 5, 6, Hylurgus piniperda (natural size and magnified).

and firs, they destroy large numbers of trees in a few years. They are destitute of the prolonged muzzle of the last order, and have short antennæ, thickened towards the tips (Fig. 353). One of the most destructive species is the *Bostrichus typographus*, or the Typographer beetle (so named from the figure of its burrows), which has at different times ravaged the forests of Germany. It devours, both in the larva and perfect states, the soft wood beneath the bark, which is most essential to the vegetative processes; and thus causes the death of

Fig. 35'.—Track of Typographer Beetle.

the tree. It was reckoned that a million and a half of pines

were killed by this species alone in the Hartz Forest, in the year 1783; and that as many as eighty thousand individuals were ordinarily engaged in the destruction of each tree; whence the whole number at work in the forest at once must have been *one hundred and twenty thousand millions.*

657. Passing over the small family PLATYSOMA, which closely resembles the preceding in structure and habits, we come to the family LONGICORNES, distinguished by the great development of the antennæ, which are always at least as long as the body, and often longer. The larvæ mostly reside in the interior of trees, or under the bark; and are destitute of feet, or have them very small. They are furnished with robust mandibles, and do much injury to trees, especially those of large size, by burrowing deeply into them. They are vegetable-feeders in their perfect state also, and do great injury to plants; some attacking the leaves, and others the roots. Many of them produce a slight creaking sound, by the friction of the joint which unites the

FIG. 355.—CALLICHROMA MOSCHATA.

thorax to the abdomen. Several of them are brilliantly coloured, especially the tropical species; and some are remarkable for exhaling an agreeable musky odour. This is the case with a British species, the *Callichroma moschata*, or Musk-beetle, which is about an inch long, entirely green, or shaded with a blue or golden hue,

and very common upon willows. The genus *Acanthocinus* is remarkable for the spiny projections from its antennæ; and the species represented in the accompanying figure, derives its specific name (which means mirror-bearing) from its having a bright burnished disc on each of the elytra.

Fig. 356.—Acanthocinus speculifer.

658. The succeeding family Eupoda, is composed of Beetles, which are chiefly remarkable for their habit of feeding upon the stems and leaves of aquatic plants, and upon those of the Liliaceous tribe. One species, the *Crioceris Asparagi*, which is of a blue colour, with the thorax red, and the elytra yellowish-white, with blue markings, feeds in the larva state, on the young sprigs of asparagus; and is sometimes so abundant, as to do considerable damage to the gardener.

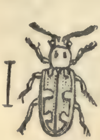


Fig. 357.—Crioceris Asparagi.

659. The sixth family of the Tetramerous section, that of Cyclica, presents many points of interest, on account of the singular forms, and remarkable habits, of many of the species which it includes. The name of the family is derived from the circumstance that, in its typical forms, the body is of a circular or oval shape; the insects composing it are usually of small size, but are often ornamented with metallic and brilliant colours; they are generally slow in their motions, timid, and fall to the ground when an attempt is made to seize them, folding their antennæ and legs beneath the body; many species leap well. The larvæ have six feet, and a soft body; they feed, like the perfect insect, upon the leaves of different vegetables, where they ordinarily affix themselves by means of a glutinous secretion; and they frequently undergo their change into the pupa state in the same situation, the cast-skins of the larvæ being crumpled up at the extremity of the body of the pupæ. The first tribe of this family consists of the *Cassidariæ*, or Tortoise Beetles; these have a flattened body, sur-

rounded by a margin, which is formed by a prolongation from the thorax and elytra, and which even conceals the head; and they are able to lie so close upon the surface of the leaves, that no part of the body or limbs is visible. Their colours are much varied, and often very prettily arranged in spots, points, rays, &c. The commonest species in this country is the *Cassida viridis*, which is no more than 1-16th of an inch long, of a green colour, with black thighs. Its larva, which lives on thistles and artichokes, has a very flat body, with spines set on the edges; and it has the singular habit of covering itself with its own excrement, which it attaches in a mass together, and carries on a sort of fork, arising from its tail. The pupa, also, is very flat, with thin-toothed appendages at the sides of the body; and its thorax is broad, and prolonged forwards in a rounded expansion, which covers the head.

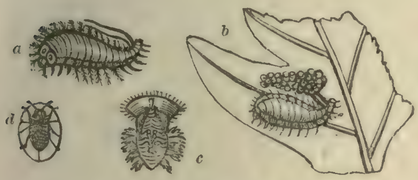


FIG. 358.—CASSIDA VIRIDIS, IN ITS DIFFERENT STATES; *a*, larva; *b*, the same on a leaf, with its covering of excrement; *c*, pupa; *d*, perfect insect.

660. In the sub-family *Chrysomelinæ*, or Golden Beetles, this expansion of the thorax is generally wanting; the body is usually of a hemispheric or ovate form, the base of the thorax being as broad as the front edge of the elytra; and the surface is usually bespangled with the most brilliant hues, in which blue, green, and gold, are pre-eminently conspicuous. Their motions are generally slow, and many of them are destitute of wings. Of the genus *Chrysomela*, the *C. populi* is one of the commonest British species; it is of a blue-black colour, and has red elytra, tipped with black; and it is found upon the willow and poplar, in the larva as well as in the perfect state. As in the preceding group, the exuviæ of the larvæ are found collected into

FIG. 359.—CHRYSOMELA POPULI; *a*, Larva; *b*, Pupa; *c*, Imago.

a mass, at the extremity of the body of the pupa; and, in some instances, the larva, before undergoing its transformation, attaches itself to the leaf by a glutinous exudation. Of the apterous group, the *Timarcha* is the principal genus; and the *T. lævigata* is a common British species, varying in length from half to three quarters of an inch, and frequenting woods, turf, and low herbage. It crawls slowly, and emits a reddish-yellow fluid from the joints when disturbed; from which circumstance it is commonly known by the name of the Bloody-nose Beetle. The larvæ bear a strong resemblance to the perfect insect, both in appearance, sluggishness of movement, and general habits; when disturbed, they roll themselves up in the manner of a Wood-louse. The sub-family *Galerucinæ*, may also be mentioned as containing the genus *Haltica;* which is composed of a group of small brightly-coloured Beetles, whose larvæ devour the leaves of cultivated vegetables, and occasionally commit great devastations by their numbers and voracity. One of them occasionally attacks the turnip in this country; and from its great leaping powers, may well be designated the *Turnip-flea*. The Turnip-fly belongs to quite a different group. (§ 686.)

FIG. 360.—HALTICA NEMORUM, OR TURNIP-BEETLE; natural size and magnified.

661. Section IV.—TRIMERA. The Beetles of this section are, for the most part, of small size, and not very numerous. Their habits are various, a portion feeding on Fungi, and the remainder chiefly upon *Aphides*. To the latter section belongs the genus *Coccinella*, of which several species are known in this country, under the name of Lady-birds, or Lady-cows. They sometimes appear in great profusion, and have created much alarm. It is erroneous to suppose, however, that they do any injury to vegetation; for, on the contrary, they are of great benefit to plants, by feeding on the Aphides which infest them; and this they do both in the larva and perfect states.

FIG. 361.—COCCINELLA 7-PUNCTATA.

ORDER II.—Orthoptera.

662. In many respects the Insects of this Order resemble the Coleoptera; and they are closely connected with that group by the family Forficulidæ, or *Earwig* tribe, which partake of the characters of both. But they differ from the Beetles, in the softer covering of their bodies; in the partially membranous character of the anterior pair of wings, which seem intermediate between the horny elytra of Beetles and the membranous wings of other insects, and which do not meet when closed along the central line of the back; and in the fan-like manner in which the posterior wings are folded up beneath them, which is permitted by the straight direction of their veins. They differ also in their metamorphosis; for, whilst that of the Beetles is complete, that of the Orthoptera, is only partially so,—the larva

Fig. 362.—Larva and Pupa of great green Grasshopper.

and pupa closely resembling the perfect insect in form, walking and feeding in the same manner, and differing in little else, than the absence of the wings and wing-covers, which are gradually and visibly developed in the pupa.—This Order comprises numerous well-known insects, often of large size and splendid colours, such as Grasshoppers, Locusts, and Walking-Leaves;—as well as Cockroaches and Earwigs. Some of the largest of known insects belong to it; a few species attaining a length of eight or nine inches, and an equal expansion of wings. Comparatively few of this Order are inhabitants of temperate regions; and it attains its greatest development, both as to the number of species and individuals, their size, and their colour, between

the tropics. All the known Orthoptera are terrestrial, both in their perfect and two previous states. Some are purely carnivorous, and others are adapted to a mixed diet,—the Cockroaches, for example, being capable of feeding on almost any kind of organised matter; but the greater number feed upon plants. Hence from their large size, and the enormous quantity which each individual can devour, they are among the most destructive of all the Insect tribes, when they appear in large numbers. This is particularly the case with the Locusts in warm countries; the ravages of which not unfrequently cause famine and pestilence, both among men and beasts. Some details upon this subject will be given in the latter part of this volume.

663. Before treating of the true Orthoptera, we shall first notice the family FORFICULIDÆ; which has been raised by some into a distinct order, under the name DERMAPTERA, or leathery-winged (§ 637). The *Earwigs* and their allies, of which this group is composed, have the anterior wings formed into elytra, possessing a consistence intermediate between that of the horny elytra of Beetles, and the parchment-like anterior wings of the Orthoptera; they are of small size; and they meet, when folded together, upon the central line, as in Beetles. The posterior wings are folded across when at rest, as in the preceding Order, but the part thus doubled down is itself folded in a fan-like mode, as in the Orthoptera. These insects are further distinguished by the two large appendages at the posterior part of the body, which form a pair of forceps (Fig. 306). They are very common in damp situations, where they assemble in troops under stones and the bark of trees; they do much injury to the flowers and fruits of our gardens, and they will devour the bodies of their dead companions. Their forceps appears to serve as an instrument of defence; whether it answers any other purpose is not known. Their common name is derived from the incorrect notion, that they have a peculiar tendency to creep into the ears of sleeping persons.

664. The proper Orthoptera may be divided into two principal sections; in the first of which the legs are nearly of the

same length and adapted for walking or running, whence they are named CURSORIA; whilst in the second, the SALTATORIA, the thighs of the hind-legs are of disproportionate length, and are adapted for leaping. These two groups also differ in the arrangement of the wing-covers and wings, when closed; for they usually rest horizontally in the body (and consequently more in the manner of those of the Beetles) in the first; whilst in the second they meet at an angle, like the two sides of a roof. The second section is further distinguished by the creaking sound, which the males have usually the power of emitting, by the friction of their legs against the body.

665. The first section may be divided into three families, which differ considerably from each other in general form,—the BLATTIDÆ, or *Cockroaches;* the MANTIDÆ, or *Mantis* tribe; and the PHASMIDÆ, or *Spectre* insects. In the first of these, the legs are adapted for running; in the second, the fore-legs are converted into claws for seizing the prey; and in the third, the limbs are adapted only for walking or creeping.—The BLATTIDÆ are in many respects intermediate between the Forficulidæ and the more typical Orthoptera; in fact, their general resemblance

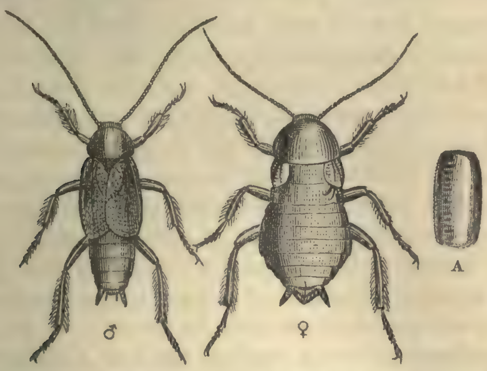


FIG. 363.—BLATTA ORIENTALIS, MALE AND FEMALE.

to the Coleoptera occasions them to be commonly regarded as Beetles. These well-known insects are now pretty generally

diffused over temperate climates; although most of the species are believed to have been originally natives of tropical regions, where only they attain their full development. They are nocturnal in their habits, and active in their movements along the ground; their powers of flight are usually inconsiderable, the wings being usually small in proportion to the size of their bodies; and they are extremely voracious, devouring with avidity almost every kind of organised matter. In cold climates the wings are scarcely enough developed, even in the male, to raise the body from the ground; whilst in the female they are almost entirely absent. The species which is commonest in this country, the *Blatta orientalis*, is so named from its being supposed to have been originally a native of the East Indies; it has, however, been so long domesticated with us, that its time and mode of introduction are uncertain. In common with most other species of Blatta, it ejects a dark-coloured fluid from the mouth, emitting a very disagreeable odour, of which it is difficult to get rid, and attaching itself to whatever the insect has crept over. The tropical species are larger and more voracious; one of them, which attains the breadth of six inches when its wings are expanded, is known in the West Indies by the name of *drummer*, from the sharp knocking sound which it produces, and which is sometimes kept up through a whole night by several individuals replying to each other; and it is said to attack sleeping persons, and even to devour the extremities of the dead.—Notwithstanding the disgusting character which attaches to these insects, on account of their appearance and habits, they present several points of much interest to the Naturalist, especially in regard to their mode of depositing their eggs. Instead of being discharged separately, the eggs are collected together and deposited at once, enclosed in a large horny case or capsule (equalling half the abdomen of the female in size), and generally of a more or less oval and flattened form, like a small bean with one edge more flattened than the other (Fig. 363, A). Along this edge there is a slit, from end to end of the capsule; and the plates which form the edges of this slit are jagged or toothed, fitting closely to each other. The interior

of this capsule is divided into two spaces, in each of which is a row of separate chambers, every one of them enclosing an egg. The capsules are attached by means of a glutinous secretion, in such situations as the females select as most fit for their reception; and the slit part is strongly coated with cement, so as to be even stronger than the other parts. In this capsule, the young larvæ are hatched; and they immediately discharge a fluid, which softens the cement, and enables them to push open the slit; through this they escape, and the slit then shuts again so closely, that it appears as entire as before.

666. The MANTIDÆ are purely carnivorous insects, of which none are natives of this country. They differ much from the Blattidæ in the form of the body; which, instead of being flattened and oval, is narrow or compressed, and lengthened. The first pair of legs is enormously elongated, and forms a very powerful organ of attack. These insects frequent trees and plants; and the forms and colours of their wings and bodies are

FIG. 364.—MANTIS, IN THE ACT OF SEIZING A FLY, WITH A YOUNG ONE JUST HATCHED.

often so adapted to those of the leaves and twigs which surround them, as to give them remarkable power of eluding observation. Most of the species asume, when lying in wait for their prey, an attitude which has been mistaken by the inhabitants of the countries where they are found, for that of prayer; and the

names commonly given to the Insects are such as to express this. Thus the best-known species, which is very common in the south of France and Italy (Fig. 364), has received the name of Mantis *religiosa*, the Praying Mantis, or Soothsayer; and is termed by the French *prie-Dieu*. This is regarded by the Turks as an object of superstitious veneration; and many absurd stories are on record, in regard to its habits. The peculiar attitude in question, however, is nothing else than the position in which the prey is most readily seized;—the front of the thorax being elevated, and the two fore-legs being held up together like a pair of arms, prepared to seize any animal that may fall within their reach. These insects are extremely voracious; and, if kept together without food, they will fight until one is killed, the victor then devouring his conquered adversary.—The eggs are included in a capsule, as in the Blattidæ.

667. The third family of the Cursoria, that of PHASMIDÆ, or *Spectre Insects*, is also restricted to warm climates; and consists of a small number of extremely curious species, commonly known under the names of *Walking-Sticks*, *Walking-Leaves*, &c., from their resemblance to those objects. Their whole structure indicates a sluggish mode of life; they subsist solely upon vegetables, and crawl slowly among the branches of low shrubs, devouring the young shoots. In fact, their mode of life bears a strong analogy to that of the Sloths among Mammalia. Their means of escape from enemies consist entirely in their very close resemblance to the objects in the midst of which they live. Some of them are destitute of wings, and have the appearance of dead twigs; the legs being generally extended in a straight line so as

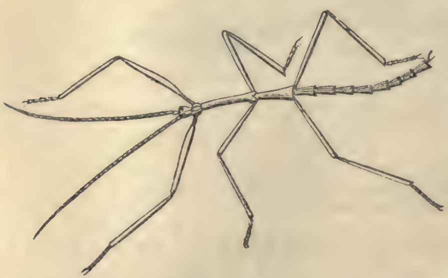


FIG. 365.—PHASMA (BACTERIA) FRAGILIS, OR WALKING-STICK.

to look like the lateral twigs; whilst the absence of motion in the Insect for a long period adds strength to the deception. Others, which possess wings, have still the same general appearance; these organs being laid flat along the back, so as not to extend beyond the body. In others, again, the wings have the form and aspect of withered leaves (Fig. 366); whilst the wing-covers are very short. And lastly, there are a few, in which the wing-covers are of a brighter hue, and of larger size, covering in the wings, and giving to the whole animal the appearance of a fresher leaf. These curious insects are for the most part natives of the East Indies, the East Indian Archipelago, Australia, and South America. Their larvæ differ but little from the perfect insects, except in their colours and in the absence of wings; and there are several species, as we have seen, in which these are never developed. It not unfrequently happens that they lose a limb by violence; and this is repro-

FIG. 366.—PHYLLIUM SICCIFOLIUM.

duced, provided the complete growth of the animal has not been attained. The eggs are laid separately, in the usual manner.

668. The section SALTATORIA consists of numerous species

allied to the well-known Crickets, Grasshoppers, Locusts, &c.; all of them being adapted, by the peculiar conformation of their hind-legs, to move by leaping rather than by running. Besides this peculiarity, they all agree in depositing their eggs in the ground: and they generally effect this by means of a horny tubular prolongation of the last segment of the body, or *ovipositor*, such as we shall meet with in the order Hymenoptera. There are three distinct groups in this section;—namely, the ACHETIDÆ or *Crickets;* the GRYLLIDÆ or *Grasshoppers;* and the LOCUSTIDÆ or *Locusts;* but the differences between them are scarcely such, as to entitle them to rank as distinct families. The *Crickets* are essentially inhabitants of the ground, in which many of them burrow, both in the larva and perfect states; few of them have any powers of active flight. One of the most important species of this family is the *Gryllotalpa vulgaris*, or *Mole-Cricket* (Fig. 300), which derives its name from the peculiar similarity in its anterior extremities, and from the resemblance in its habits, to those of the Mole. It is about an inch and a half long, and of a brown colour. In making its burrows, it cuts through or detaches all the roots of plants which it encounters; but it does not do this so much for the purpose of feeding upon them, as to make a passage in search of insects and worms. The female forms, in June and July, at the depth of about six inches from the surface, a rounded cell, smooth within, and resembling with its gallery a bottle with a long bent neck; in this she deposits from 200 to 400 eggs; and the young remain in society for some time after they are hatched. The larvæ are at first white; but in other respects they resemble their parents, except in their smaller size and their want of wings; after their first moulting, they disperse, and soon gain their darker colours; and they are about three years before they arrive at the perfect state. Their wings are so little developed, that the possibility of the flight of the insects has been denied. It is remarkable that the various species of this singular genus should be spread over the whole globe. The *House-Cricket* (Fig. 367) is too well known to require particular description; it takes up its abode in the neighbourhood of the fire-places of rooms on the ground-

floor, sometimes even burrowing into the mortar, even within a few inches of the fiercest fires; and here it remains during the winter months, becoming torpid in its haunts, if the fire be discontinued. In the summer, however, it frequently goes forth to the gardens, and seeks a habitation in the crevices of garden-walls, &c., as if it then found heat enough out of doors. The *Field-Cricket* is much larger, and also rarer, than the preceding; it frequents hot sandy districts, in which it forms its burrow at the side of footpaths, &c., in situations exposed to the sun, to the depth of from six to twelve inches; and sits at its mouth watching for its prey, which is said to consist of other insects. This is one of the most noisy of all the Crickets.

FIG. 367.—HOUSE-CRICKET.

669. The *Gryllidæ*, or *Grasshoppers*, are distinguished from the preceding by the roof-like position of the wing-covers, which in the crickets fold horizontally; but agree with them in having long thread-like antennæ, and a talc-like spot at the base of the wing-covers in the males. They are distinguished, on the other hand, from the Locusts with which they agree in the first of these characters, by the inferior robustness of the body, and the length and slenderness of the legs and antennæ. The *Gryllus viridissimus*, or Great Green Grasshopper, represented in Fig. 368, is the largest British species of this Order, and one of the largest of our native insects; its length being about two inches, and its breadth when the wings are expanded being three inches and a half. Many species of this genus are destitute of

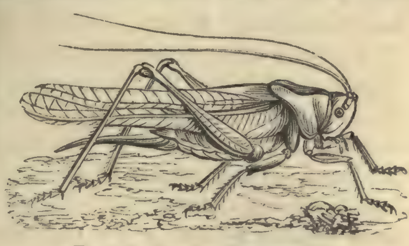


FIG. 368.—GRYLLUS VIRIDISSIMUS.

wings, or have only small wing-covers. Of their voracity a curious instance is mentioned by Mr. Westwood; who states that on one occasion he placed a specimen of the large green species in a box, together with one of its legs which it had accidentally jerked off; and on opening the box the next morning, half the leg was devoured. Amongst the foreign species of this group, there are some which bear a most singular resemblance to the fresh leaves of various plants.

670. The last group of this Order consists of the various tribes of migratory *Locusts*, together with several which are ordinarily ranked as Grasshoppers, but which agree with the Locusts in the shortness of their antennæ, and the robustness of their bodies and limbs (Fig. 369). These leap with much greater energy than the preceding, and have a much longer-sustained flight. The powers of devastation possessed by the Locusts are almost inconceivable; for they are produced in vast numbers, and live in societies, so as speedily to destroy the vegetation of the spot on which they have settled. Thence they take their flight in vast multitudes to adjoining districts; and so great is the number of which these swarms consist, that it is not speaking figuratively to say that the sky is darkened by their passage. Their ravages usually continue until they are checked for want of a further supply of food; for as the instinct of the Locusts leads them to continue their flight in the same direction, they are at last stopped either by the desert or the sea; and sometimes a storm, carrying them out of their course, or hurrying them on in it,

FIG. 369.—PNEUMORA.

effects a clearance much more speedily than any other cause could do. Of the cause of the occasional appearance of the Locusts, in such vast multitudes, no satisfactory explanation has been given. Of these Insects there are several different species, which are distributed over the tropical and the warmer temperate regions of the globe; and in many parts they are used as food by the inhabitants of the countries they infest.

Order III.—NEUROPTERA.

671. The Neuroptera correspond with the two preceding Orders, in having a mouth adapted for mastication, but differ from them as to the conformation of the wings; the anterior as well as the posterior pairs being here membranous and transparent. In both pairs of wings, the veins form a very beautiful and minute network, subdividing and uniting again, so as to divide the whole surface into a large number of minute cells, which much exceed in number those of the wings of any other tribe of insects (Fig. 370). Although the posterior wings are usually as large as the anterior, or sometimes even larger, they are occasionally much smaller, and may even be altogether wanting.

675. The body of the Insects of this Order, which contains the well-known *Dragon-flies*, *May-flies*, *Ant-lions*, *White Ants* or *Termites*, and others, is generally prolonged, and destitute of any very hard integument. These insects are of intermediate size; none of them exceeding in dimensions the largest Dragon-flies of this country; whilst none exhibit the minuteness of some Hymenoptera and Coleoptera. They differ in the character of their metamorphosis, as well as in their adult structure; for in some the metamorphosis is complete, the larva undergoing a marked change of form; and in others there is not much difference, except in the absence of wings, between the larva and perfect insect. By these differences the Order may be divided into two sections; in the first of which the insect is active during the whole of its pupa state; whilst in the second, it is quiescent, except just before its last metamorphosis. The first of these

groups may again be subdivided into three families;—the LIBELLULIDÆ or *Dragon-flies*;—the EPHEMERIDÆ, or *May-flies*; and the TERMITIDÆ or *White Ants*. In the first two of these, the larvæ and pupæ are inhabitants of the water, and respire by means of peculiar organs placed along the sides or at the extremity of the abdomen; whilst in other respects, they nearly resemble the perfect insect. They creep out of the water to undergo the final metamorphosis.

673. Section I. The LIBELLULIDÆ, or *Dragon-flies*, are well-known insects; being easily distinguished by the slender form of their bodies, their varied colours, their large gauze-like wings, and the rapidity of flight with which they pursue other insects on which they prey. They have a large head, of rounded form, furnished at its sides with two very large compound eyes, and

se stingers –
animals.

FIG. 370.—LIBELLULA CANCELLATA.

with three ocelli, situated upon its upper surface. Most of this tribe frequent the neighbourhood of water; and may be frequently seen skimming over the surface of ponds or streams, in search of flies, gnats, and other small insects. An American species has been recently described by Mr. Newport, which seems to be actually provided with *branchial* or gill-like appendages, even in its perfect state; and the habits of this insect appear to be pecu-

liarly aquatic. The eggs are deposited upon aquatic plants, and the larvæ are thus produced in the element in which they are at first to reside. The head of the pupa is remarkable for the

FIG. 371.—A, the pupa with its mask. B, the same with the mask closed, and discharging a current of water.

singular form of the portion which takes the place of the lower lip; this is a kind of mask, composed of several pieces, and covering the mandibles, maxillæ, and nearly all the under side of the head, when it is closed together; but being capable of extension and unfolding, and being furnished with a pair of sharp claws at its upper part, so as to become the instrument by which the animal seizes its prey. The posterior end of the abdomen, in the early state of the Dragon-flies, is usually the seat of the respiratory function. This is commonly performed by means of three leaf-like membranous organs, which are situated inside the extremity of the intestine, or sometimes within a sort of prolonged pyramidal tail; in using these, the animal draws a supply of water into the rectum; and then forces it out violently, by which act it also impels itself through the water. The succession of jerks thus produced, is the chief means of locomotion of the larvæ of the Dragon-flies, and serves to distinguish them from all other aquatic larvæ; so that they are very easily recognised. Several

species of Dragon-flies exist in this country; the largest, which is probably not surpassed in size by any others, measures two inches and a half in length; but the foreign species are usually more brilliantly coloured.—In the *Agrions*, the wings stand perpendicularly when in repose, instead of horizontally as in the Dragon-flies; and the mouth is somewhat differently constructed. The species represented in the accompanying figure is of a golden-green, or bluish-green colour, with the wings blue; and in common with many other less conspicuous species, it is an inhabitant of Britain.

FIG. 372.—AGRION VIRGO.

674. The EPHEMERIDÆ, or *Day-flies*, receive their name from the short duration of their lives in the perfect state. The history of their early condition has been already given (§ 632).

FIG. 373.—EPHEMERA.

Their last change takes place near sunset on the fine days of summer and autumn; and they are sometimes produced in such vast numbers at one time, that the ground is covered with them after their death, and their bodies are carted away as manure. They take no food after their final change; and as the propagation of the race is then their only object, they die almost as soon as it has been performed, often in a few hours after they have quitted the water,—the duration of their lives in their previous conditions having been two or even three years.

675. The TERMITIDÆ, or *White Ants*, are terrestrial, active, and carnivorous or omnivorous, during all their stages. In

several points of their structure, they resemble the Orthoptera; whilst in their habit of living in societies, they resemble a large proportion of the Hymenoptera. There is, however, as we shall hereafter see, a considerable difference in the duties of the several tribes of which these communities consist. A more particular account of their operations will be given in a later part of this volume; and at present it will be sufficient to say, that the larvæ resemble the perfect insect, except in the absence of wings, and are the *workers*. Among the adult insects there are some, which never acquire wings, and in which the reproductive organs are not developed; these, which are termed the *soldiers* (Fig. 374), have the head much larger and longer than that of the larvæ, and the mandibles are very long and cross each other; they are far less numerous than the larvæ, and live near the outer surface of the nest, so that they are the first to make their appearance when it is attacked; and they are also stated to compel the workers to labour. The winged males (Fig. 375) and females,

FIG. 374.—SOLDIER TERMES.

FIG. 375.—TERMES in perfect state.

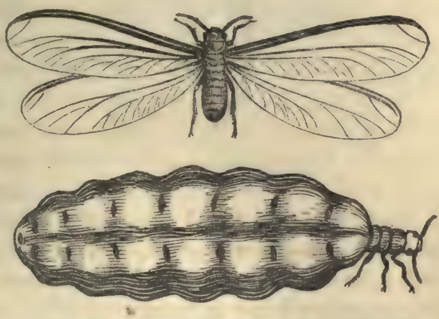


FIG. 376.—QUEEN in the winged state, and filled with Eggs.

when they have arrived at their perfect state, quit their habitation, and fly abroad during the evening or the night, in great

numbers; they lose their wings before the morning, however; and the greater part of them, falling to the ground, become the prey of birds, reptiles, &c. The females, however, are sought by the workers, who imprison them in royal chambers, as they have been termed, in the centre of the nest. The abdomen subsequently attains an enormous size, from the quantity of eggs it contains; and these, when laid, are carefully tended by the workers, and defended by the soldiers.—Some small species belonging to this family, but not at all resembling the true Termites in habits, are found in our country; one of them, which is found in collections of dried plants, is remarkable for producing a slight ticking noise; it is represented of its natural size, and magnified, in the accompanying figure.

FIG. 377.—PSOCUS PULSATORIUS.

676. Section II. Of the division of Neuroptera in which a more complete metamorphosis occurs, the pupa passing into an inactive condition, the family of MYRMELEONIDÆ, or *Ant-lions*, is one of the most remarkable. As its peculiar habits in the larva state have already been elsewhere described (ANIM. PHYSIOL. § 697), they need not be here dwelt on. When the larva has attained its full growth, and is ready to assume the pupa state, it spins a perfectly round cocoon of a silky matter, the exterior of which it covers with sand; and from this the perfect insect makes its escape at the end of fifteen or twenty days. None of this group are found in Britain.

FIG. 378.—MYRMELEO.

677. The family HEMEROBIIDÆ, which is closely allied to the preceding, is remarkable for the exceeding brilliancy of the eyes in most of the species, and for the delicate structure and varied colours of the wings. The eyes often resemble the most

highly-polished gold; and the wings frequently reflect the prismatic colours; so that, although of small size, these insects are very conspicuous. They are for the most part inhabitants of temperate climates; and many species abound in Britain. They usually fly during the twilight, remaining inactive during the day; and they emit a very disagreeable odour when handled. The females deposit their eggs upon plants, attaching them at the extremity of a long slender footstalk, the base of which is fastened to the leaf; this footstalk is composed of a white viscid matter, discharged by the female at the time of laying her egg, and speedily hardening by exposure to the air. The eggs, thus curiously fixed in small clusters, have the appearance of minute fungi. The larvæ are extremely voracious, and especially attack the Aphides; unlike the Ant-lions, however, these Aphis-lions (as they have been termed) do not remain concealed in one spot, but wander in search of their prey where it is to be found in the greatest abundance. So ravenous are they, that they do not require more than half a minute to suck the juices from one of the largest Aphides; and they not unfrequently attack each other, the conqueror in like manner sucking the body of the vanquished. During the summer they arrive at their full growth in about fifteen days; they then spin a silken cocoon, in which they enter as inactive pupæ during the winter; and come forth in the succeeding summer.

678. The remaining families of this Order may be very briefly noticed. The Sialidæ are a small group of moderate or large-sized Neuroptera, having very large anterior wings. They are nevertheless slow and inactive in their habits, and frequent the neighbourhood of water, in which they pass their larva state. The ordinary species *Sialis lutaria*, or *May-fly*, is a well-known bait with the angler, being produced during the spring months in large quantities; it is of a dull brown colour, and may be found on the walls or palings near the water. The larva is furnished with appendages for aquatic respiration, strongly resembling those of the Ephemera; but when arrived at its full growth, it quits the water and burrows into the adjoining bank, in which it excavates a sort of cell. Here it

is transformed into a pupa, which remains inactive, with its limbs laid along the breast, but which is lively when disturbed; and here, too, it undergoes its final change.

679. The PANORPIDÆ are known under the name of *Scorpion-flies*, on account of the remarkable conformation of the posterior extremity of the abdomen in the male. The sixth and seventh segments are very slender and somewhat curved upwards, so as to constitute a sort of tail; whilst the eighth is greatly thickened, forming an oval mass, armed with a pair of forceps, and capable of free motion in any direction. The species represented in Fig. 379 is a very common British insect, frequenting hedges and woods. The Scorpion-flies are very active, and prey upon other insects in the perfect state. The abdomen of the female is also prolonged into an *ovipositor;* by which she can deposit her eggs in deep holes or crevices.

FIG. 379.—PANORPA COMMUNIS.

680. The RAPHIDIIDÆ are commonly known as *Snake-flies*, from the elongated form of the head and neck, and the facility with which they move the front of the body in different directions. They are of comparatively small size, agile in their movements, and possessing powerful jaws; they are chiefly found in the neighbourhood of woods and streams; and they prey upon other insects inhabiting the same situations. Finally, the MANTISPIDÆ seem to connect this order with the preceding; having the mouth formed upon the plan of that of the Neuroptera; but having the fore-legs converted into prehensile claws, and the first segment of the thorax lengthened so as to elevate them, almost exactly as in the Mantis.

681. We shall next mention the small intermediate group of PHRYGANEIDÆ, or *Caddice-flies*, which are by some Entomologists regarded as constituting an aberrant family of the Neuroptera, whilst others raise them into the rank of a distinct Order, TRICHOPTERA,—a name derived from the hairy covering

with which their wings, as well as their bodies, are beset. In this character, as also in the arrangement of the nerves of the wings, they bear a strong resemblance to the Lepidoptera.

682. These Insects are chiefly remarkable on account of the habits of the larvæ, which are well known under the name of *Caddice-worms*. These reside in cylindrical cases, open at each end, to which they attach various matters, as bits of stick, weeds, pebbles, or even small living shells, by the assistance of silken threads, which they spin from the mouth. These cases they bear about with them; protruding the three first segments, with their legs, when they creep forwards; and withdrawing these upon the slightest alarm. They are never known to quit these cases of their own accord. Different species appear to prefer different materials for the construction of their cases; but they have the power of employing almost any which fall in their way, when there is a deficiency of those usually preferred. The food of some of the larvæ is vegetable; but others prey upon small aquatic larvæ, such as those of the Neuroptera.—When about to assume the pupa state, the larvæ fix their cases to some solid substances beneath the water, and close the two extremities with a kind of grating, that admits of the passage of water through the tube, which is necessary for respiration. A short time before they are to assume their perfect form, they make their way out, by means of the pair of hooked jaws, with which they are then furnished, and swim about with great activity by means of the two hind legs, crawling occasionally upon the four first. In order to throw off their pupa-case, the larger species crawl up plants out of the water; but the smaller ones merely come to the surface, and there undergo their transformation,—using their old envelope as a boat, out of which they rise to

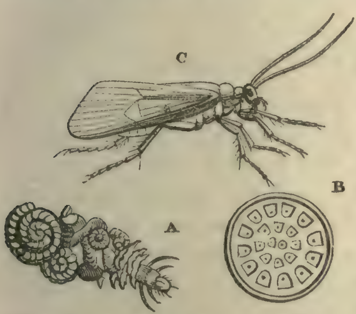


FIG. 380.—PHRYGANEA GRANDIS.—A, Larva in its case; B, grating; C, Imago.

expand their wings, much in the same manner as Gnats. The perfect Caddice-flies run with great agility, but their flight is awkward,—except in some of the smaller species, which assemble in troops and fly over the surface of the water towards sunset. They are nocturnal in their habits, and not unfrequently enter our houses, being attracted by the light. They emit a disagreeable smell when touched. These insects are very numerous in Britain; no fewer than 190 species having been described.

Order IV.—HYMENOPTERA.

683. In the membranous character of their four wings, the insects of this Order resemble the Neuroptera; but they cannot well be mistaken for them. The anterior wings are usually much larger than the posterior; and the veins or nerves* are much fewer in number than in the Neuroptera, and do not form a close network by their ramifications, as in that Order. In some of the minute species, the wings are almost, or even entirely, destitute of nerves. Another character furnished by the wings consists in the connection of the anterior and posterior wings on each side, during flight, by means of a series of minute hooks along the front edge of the latter, which catch the hinder margin of the other, so as to produce one continued surface on each side.—The principal character of the Order, however, is derived from the structure of the mouth; for, although considered as *mandibulate* insects, the Hymenoptera are much better fitted for imbibing their nourishment by suction, than for obtaining it by mastication (§ 614). The Hymenoptera are also peculiarly distinguished by a prolongation of the last segment of the body in the females, into an organ,—which is, in one division of the Order, a *sting*,—and in the other, an *ovipositor*, or instrument for the deposition of the eggs, usually possessing the power of boring a hollow for their reception.

* These terms are used to mean the same things; namely, the hard framework on which the membrane of the wing is extended. They must not be understood as indicating any analogy to the veins and nerves of higher animals.

684. The Hymenoptera are further remarkable for the great development of their *instinctive* faculties, and of their *locomotive* powers. It is in this order that we find the most remarkable examples of contrivance, and of skilful adaptation of means to ends; but this adaptation results, it would appear, not from an exercise of *intelligence* on the part of the animals themselves (as in Man and the higher Vertebrata), but from their blindly following out a path laid down for them by the Almighty Designer (ANIM. PHYSIOL. § 475). That the two classes of faculties just mentioned should attain their highest development in the same group (the Neuroptera may, perhaps, be included in this statement), is a very remarkable and interesting fact. Considering these powers as those which are peculiarly characteristic of the *animal kingdom*, we may regard these groups of Insects as the types or centres (§ 35) of that kingdom. As we descend the scale, we find these powers gradually disappearing, whilst the organs of vegetative life (which, as we have seen, are of comparatively small size in Insects) gain the predominance, so that in the Zoophytes we have an evident approach to the Vegetable kingdom. On the other hand, as we ascend the Vertebrated series, we find the Instincts gradually superseded by Intelligence, which in Man becomes the sole director (at least in the well-governed mind) of the actions, keeping the instincts in subordination; and through his immortal soul we are connected with that kingdom of *pure Intelligence*, in which we have reason to believe that *Mind* exists unfettered by the imperfections of its corporeal instruments, and of which we are encouraged to hope that we shall ourselves be sharers, when "this corruptible shall have put on incorruption."—The mutual adjustment of the various instinctive actions of a large number of individuals, so that they all work together towards a common end, like the parts of a machine, is nowhere so remarkable as in the *social* Insects, which are principally restricted to this order; and the Bees, Wasps, Ants, Ichneumons, Saw-flies, Gall-flies, and many other groups contained in it, have consequently attracted the attention of the observer of nature from a very early period.

685. The Insects of this Order undergo a complete meta-

morphosis; the larvæ being more imperfect than those of almost any other tribe; and the pupæ being quite inactive. In the greater proportion of the order they are destitute of feet, and resemble little worms. Their support is provided for, either by the deposition of the eggs in situations where the future grub will be furnished with an ample supply of food—the parent being directed to these by an unerring instinct,—or by the active exertions of the parents, which convey to the young the food which they have themselves collected; or by similar exertions on the part of a race destitute of peculiar sex (hence termed *neuters*), on whom this charge more especially devolves. When

FIG. 381.—LARVÆ OF BEE, NATURAL SIZE, AND MAGNIFIED.

FIG. 382.—PUPA OF BEE.

arrived at their full growth, and after undergoing several previous changes of skin, the larvæ are transformed into inactive pupæ; in which all the limbs of the future insect are visible, encased in distinct sheaths, and folded on the under surface of the thorax. During this part of their existence they take no food. In their perfect state, these insects, for the most part, take but little nourishment; and this consists almost exclusively of the nectar of flowers. Many of them, however,—such as the Wasps,—attack and destroy other insects; but these are often destined, not for their own support, but for the nourishment of the young.—This Order is of considerable extent, being inferior only to the Coleoptera; and it has been estimated to contain one-fourth part of the whole Insect population. It attains its greatest development in warm climates; for, of the numerous species inhabiting this country, the greater part are of very small size, and some are almost of even microscopic minuteness. None of the species attain any great dimensions; very few of them exceeding, or even attaining, two inches in length, or three in

the expansion of their wings. The duration of their lives, from the hatching of the egg to the final change, is believed never to exceed a year.

686. This Order may be primarily divided into two groups, according to the nature of the organ in which the body of the female terminates;—the end of the abdomen being prolonged, in the TEREBRANTIA, into a saw or borer for the deposition of the eggs;—whilst, in the ACULEATA, it is formed into a sting or piercer connected with a poison-reservoir. In the former group, the number of joints in the antennæ is extremely variable; whilst in the latter, it is always twelve in the female, and thirteen in the male. The Terebrantia may be again divided into the PHYTIPHAGA, of which the larvæ feed upon vegetable matter; and the ENTOMOPHAGA, in which they generally feed parasitically upon living insects. The Aculeata are in like manner divided into the PRÆDONES, or predaceous tribes, which do not collect pollen, and in which the larvæ feed upon other insects stored up for them, or upon fluids stored up by the neuters; and the MELLIFERA, in which the larvæ feed upon honey or pollen-paste, collected and stored up for them. All these have characteristic distinctions in their adult form; on which it would not be accordant with the character of this work to dwell minutely. The division of the Order into sections may be better understood from the following tabular arrangement of them:—

Possessing ovipositor—TEREBRANTIA	*Larvæ vegetable-feeders*	I. PHYTIPHAGA.
	Larvæ parasitic	II. ENTOMOPHAGA.
Armed with sting—ACULEATA	*Predaceous in habits.*	III. PRÆDONES.
	Honey-collectors	IV. MELLIFERA.

687. Section I. TEREBRANTIA PHYTIPHAGA. The principal family of this section is that of TENTHREDINIDÆ, or *Saw-flies*, so named from the saw-like character and action of the ovipositor. With this instrument they make a succession of small holes in the branches or other parts of trees, into each of which they insert an egg, closing the hole with a drop of frothy fluid. The tissue in the neighbourhood of the wound swells up from its irritation; and sometimes becomes a kind of *gall*, either woody or pulpy, accord-

ing to the parts injured, which forms the abode of the larva in some cases, during its whole life as such, and up to its final metamorphosis; but in general the larvæ come forth at an earlier period, and feed upon the exterior of the leaves. They greatly resemble the Caterpillars of Lepidopterous insects; but usually differ from them as to the number of their feet, which are either restricted to six, answering to those of the perfect insect, or amount to eighteen or twenty-two. In order to undergo their change into the pupa state, they spin a cocoon, either on the earth or on the plants on which they have fed; but they do not become pupæ, until they have been inclosed in this for many months, and only a few days before they come forth as perfect Saw-flies. To this group belongs the *Athalia centifoliæ*, or *Turnip-fly*, which occasionally appears in this country in such vast numbers as to produce the greatest devastation. The larva is twenty-two-footed, and of a greenish-black colour; whence it is commonly known by the appellation of the *nigger*, or *black caterpillar* of the Turnip,—to which plant it is chiefly detrimental, by devouring the leaves, and thus totally destroying the crop in an incredibly short space of time. It was especially abundant in the south-eastern counties of England, in the years 1835, 1836, and 1837. The appearance of the black larvæ is preceded by that of the imago, a pretty yellow and black insect, which is first seen hovering over the turnip-fields about the middle of May or the beginning of June; it deposits its eggs in the soft tissue of the leaf, puncturing the cuticle by its ovipositor; and these are hatched in five or six days. In a few days

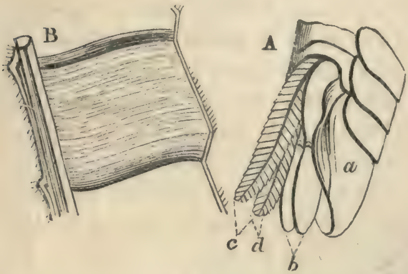


FIG. 383.—A, extremity of the abdomen of the Sawfly, showing the two saws, *c*, and their supporters, *d*, extended; *a*, the terminal joint of the abdomen; and *b*, the two internal horny sheaths. B, a small portion of one of the saws very highly magnified.

more, a whole field has been often devastated by the voracity of the larvæ, which devour the soft tissue of the leaves, leaving only their skeletons and stalks. The most effectual remedy for these attacks was found to be the introduction of Ducks into the fields, by which the plants were cleared of the larvæ more effectually than they could be by any other means. Many other species exist, however, almost equally injurious to different tribes of plants. Thus the Gooseberry is subject to the attacks of a Tenthredo, of which the larvæ—often amounting to as many as one thousand upon a single tree—devour its leaves at the beginning of summer. The Apple, again, suffers from the deposition of the eggs of another species in its fruit. And the Willow is subject to the attacks of many species, some of which devour its leaves, whilst others cause the production of galls by perforating its branches. The perfect Insects of this group are of moderate size, not exceeding an inch in length; some of them, however, are among the largest Hymenoptera inhabiting this country. Their flight is usually heavy, and is attended in the larger species with a humming noise; it seems, however, to be more agile in the hot sunshine. They come forth for the most part in the spring, having passed the winter in the pupa state; and they usually obtain their chief supply of food from the pollen or honey of flowers, especially those of the Umbelliferous tribe; some of them, however, attack and devour living insects which frequent the same plants. The ravages of these insects are restrained by the destruction of vast multitudes of *their* larvæ, through the agency of the Entomophagous, or parasitic section of this group; thus the *Lophyrus pini*, a Saw-fly which infests the Pine, is itself subject to the attacks of at least twenty parasites, of which fifteen are Ichneumonidæ.

688. The Siricidæ bear a strong general resemblance to the preceding group, both in structure and habits; but they have a stronger ovipositor, which enables them to pierce not merely the soft substance of trees or young shoots, but hard timber. The larvæ produced from the eggs thus deposited, usually reside in the interior of trees, which they perforate in various directions; often causing great destruction of the Pine forests, of which the

largest species are inhabitants. When full grown, they form a slender silken cocoon, mixed with chips of wood, at the extremity of the burrow; and here they undergo their final transformation. The perfect Insects are among the largest of the order; they are remarkable for the very cylindrical form of their bodies, and for the humming sound which they make when on the wing.

FIG. 384.—SIREX GIGANTEUS.

689. SECTION II.—In the section of ACULEATA ENTOMOPHAGA, the first family, that of CYNIPIDÆ, or *Gall-flies*, rather corresponds with the preceding in its general habits, and in the diet of the larvæ. These insects puncture, with their ovipositor, the surface of the leaves, buds, stalks, and young stems and roots, of various plants and trees; and they increase the aperture by means of the toothed edge, forming a kind of saw, with which the extremity of this organ is armed. In this aperture they deposit, besides the egg, a drop of fluid, which seems to be peculiarly irritating in its character; causing the production of tumours or *galls*, of various sizes, shapes, and colours; the solid interior of which becomes the food of the larva when hatched. It is a remarkable circumstance, that the very same tree should produce, on its different parts, galls of very different forms and of various degrees of consistency, according to the species of Cynips by which it has been punctured. The hardest is the common Gall-nut, which is employed in the manufacture of ink, and also, to a far greater extent, in the process of dyeing black (VEGET. PHYSIOL. § 399). This is produced in the Levant, upon a low-growing species of Oak, the *Quercus infectoria.* It has been recently ascertained, that the "apples of Sodom,"—

which are found on the borders of the Dead Sea, and which have been said "to appear outwardly tempting to the eye, but to turn to ashes on the lips,"—are nothing else than galls of a softer consistence, produced from the same Oak by the attacks of another species of Cynips. The "oak-apples," again, of our own country, are large galls found upon the young shoots; the leaves sometimes produce, besides the larger galls, a multitude of little spangled discs, of a reddish colour, which contain the larvæ of a small species of Cynips; the parts of fructification are sometimes attacked by a species, the galls of which hang on the catkins like a bunch of currants; and the root produces a large woody gall, inhabited by a species of Cynips, of which 1100 individuals have been found in a single gall. The Oak is by no means the only species of vegetable infected by these insects; but a larger number of Gall-flies appear to be restricted to it than to any other plant. The Rose is subject to the attacks of one species, which causes the flower-bud to be developed into a gall in a very curious manner.—An insect, considered as belonging to this family, deposits its eggs in the seeds of the most forward wild figs of the Levant. The modern Greeks, following a custom handed down to them by their forefathers, fasten several of these fruits among the later figs; and the insects escaping from them, covered with pollen, make their way into the unfertilised fruit, and thus contribute to its maturity (BOTANY, § 673). This operation is termed *caprification*.

690. The family of ICHNEUMONIDÆ may be regarded as peculiarly characteristic of the Entomophagous section. The female Ichneumon deposits her eggs, by means of her sharp-pointed ovipositor, only in the bodies of other insects,—chiefly the caterpillars of Lepidoptera, or the larvæ of the Phytiphagous section of Hymenoptera. Some of them have a very long ovipositor, which is used to insert the eggs into the bodies of Caterpillars that live beneath the bark, or in the crevices of wood; whilst those in which this instrument is short, place their eggs in or upon the bodies of caterpillars, to which they can obtain easier access. They do not confine themselves to these situations, however; but employ for the same purpose the eggs or

pupæ, still preferring the larvæ when they can meet with them. The young Ichneumons, when hatched as footless grubs,—sometimes in considerable numbers in the body of one caterpillar,—devour only the fatty parts, which are not absolutely essential to life; and the animal they infest may continue to exist for some time, thus affording them a continued supply of nutriment; but when the Ichneumons are ready to undergo their last metamorphosis, they either pierce the skin and escape, or else they kill their victim, and perform their changes within its body. The perfect Ichneumons feed solely upon the juices of flowers, and fly about with considerable agility in search of their nutriment, or of proper situations for the deposition of their eggs. It is in the genus *Pimpla*, that the ovipositor attains its greatest development, its length being in some exotic species as much as three or four inches; when not in use, it is inclosed in two long channelled filaments, which unite to receive it like a sheath. This family is extremely numerous. Probably more than 3000 species exist in Europe alone; and the number peculiar to other parts of the globe may fairly be reckoned as at least equal. Scarcely any tribe of Insects is free from their attacks; although, as already stated, the Lepidoptera are the chief sufferers. In restraining the multiplication of many Insects, which commit great injury against the Agriculturist, the Ichneumonidæ render essential service to Man; and there is no mode in which they can be said to do him any counteracting injury.

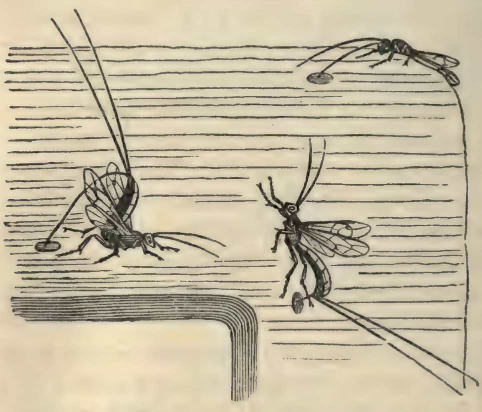


Fig. 385.—Pimpla manifestator, depositing its eggs.

691. The family CHALCIDIDÆ, or *Chalcis* tribe, is composed of a great number of parasitic insects, distinguished by their generally very minute size, (their length seldom exceeding a line or two,) their brilliant metallic or variegated colours, and their nearly veinless wings. Like the Ichneumonidæ, they are all parasitic upon other insects in their early states; the majority infesting the larvæ and pupæ; but some, from their minute size, being reared within the eggs of other insects. They are especially destructive to Lepidoptera; but they will also attack the species of most of the other Orders. Not unfrequently they deposit their eggs in various kinds of galls, formed by the agency of the preceding families; and their progeny, when hatched, attack and subsist on the larvæ inclosed within: and there are some species, whose larvæ are parasitic upon those of other parasitic insects.—Lastly, the CHRYSIDIDÆ, or *Ruby-tailed Flies*, constitute a small group, distinguished by having the abdomen attached to the thorax by a short peduncle or foot-stalk, and composed of only from three to five segments,—the remainder being formed into a tubular apparatus, capable of being drawn together or extended like a telescope, and having a minute sting or ovipositor at its extremity. These insects, although but of small or moderate size, are amongst the most splendid of our native species; being adorned with brilliant metallic tints,—usually blue and green on the head and thorax, and a fiery copper-colour or ruby on the abdomen; hence they have been termed the humming-birds amongst insects. They may be observed during the hottest sunshine, flying and running with great vivacity over walls, palings, sand-banks, and occasionally upon flowers (especially those of the Umbelliferæ) and leaves. Their economy has not been fully made out; but there is reason to believe that the females do not insert their eggs in the bodies of other insects, but take an opportunity of depositing them in the nests of the different Wild-Bees and other Hymenoptera, during the period when the latter are provisioning their nests for the support of their own progeny; which is thus starved by the intruder, whose voracity is such as to require the whole supply of food that had been prepared for the legiti-

mate occupiers of the nest. In this habit, these insects closely resemble the Cuckoo (§ 351). In many points of structure, the Chrysididæ bear a strong resemblance to the Aculeate Hymenoptera; and they may be considered as intermediate between the two great divisions of the Order.

692. Section III. ACULEATA PRÆDONES. The Hymenoptera of the Aculeate division may be usually distinguished from the Terebrantia, by the mode in which the abdomen is united to the thorax. In the *borers*, it is in general closely jointed to it,—a structure which is evidently necessary for providing the ovipositor with the requisite strength; whilst in the *stinging* Hymenoptera it is usually connected by means of a peduncle or foot-stalk, which is often (as in the Wasp) extremely slender, and of which the first appearance is seen in the Chrysididæ, as just now mentioned.—The *Predaceous* subdivision of this group contains several families; of which the most important only will be noticed in detail.

693. The CRABRONIDÆ, LABRIDÆ, BEMBECIDÆ, SPHEGIDÆ, SCIOLIDÆ, and MUTILIDÆ, may all be considered under one general description; they form a group, which may be termed, from their peculiar habits, that of *Fossores*, or Diggers; and they are commonly known as *Sand* and *Wood-Wasps*. They are solitary in their mode of life, and consequently no neuters exist among them. In general the females excavate cells in the ground, or in posts, timbers, &c.; in which they deposit—together with their eggs—various larvæ or perfect insects, and (in some species) even spiders, which are destined for the support of their progeny when hatched. Occasionally the insects composing this store are first stung to death; but sometimes they are only slightly stung, and are finally killed by the larvæ when they come forth from their eggs,—being in this manner rendered powerless, whilst their bodies are prevented from decomposing. The perfect insects are generally very active, and fond of the nectar of flowers, especially those of the Umbelliferous tribe. They delight in the hottest sunshine, flying and running over sand banks exposed to the mid-day sun, and keeping their wings in constant agitation; some of the tropical

species are among the largest of the order, and their sting is very severe. The Sand-burrowers excavate their nests, by means of powerful brushes, with which their legs are furnished; whilst the Wood-burrowers use for this purpose their strong broad mandibles, which are provided with tooth-like projections.

694. The next family, that of FORMICIDÆ, is composed of the well-known and singularly interesting tribes of *Ants* (the White Ants, improperly so called, belonging however to the preceding order); which are distinguished from all the Hymenoptera previously described, by their habit of residing underground in numerous societies, and by the existence of *neuters* among them, by which class the labours of the community are chiefly performed. The males and females, which constitute but a small proportion of each community, are alone furnished with wings; the former are the smallest. The neuters are somewhat smaller than the males, and for the most part resemble the females in conformation; but the thorax is smaller, not having to give attachment to wings. The nests of Ants are differently constructed in the different species, but all are very curiously and regularly arranged; some account of them will be given hereafter. The males and females leave the nest, as soon as they have acquired their wings; and go forth together into the air. The males soon die, without entering their former abode. Of the females some return, and deposit their eggs in the original nest; whilst others go to a distance, and become the foundresses of new colonies: they, too, lose their wings at this period, sometimes stripping them off with their own feet, in other instances being deprived of them by the neuters.—These last not only construct the nest, but most carefully tend the young grubs; supplying them with food, moving them on fine days to the outer surface of the nest to give them heat, and carrying them back again at the approach of night or bad weather, and defending them when attacked by enemies. The winged Ants having all perished at the commencement of the cold weather, the neuters only survive the winter. Some of them are larger and rather differently formed from the rest, and appear to be the *soldiers* of the com-

munity;—not only defending their own nests against attacks, but actually making war upon the nests of other species of Ants (as will be hereafter detailed), and keeping their captives in slavery. Ants are well known to be extremely fond of saccharine matters; and they seem greatly to relish the fluid which exudes from the bodies of Aphides and Coccidæ (§ 719, 720). Some species even collect Aphides into flocks, and keep them, as it were, in pastures; which they connect with their nests by means of galleries, excavated along the stems and branches of trees; and they protect the eggs of these insects in their own nests, especially in bad seasons.

695. The family of VESPIDÆ, or *Wasps*, is distinguished from the other Hymenoptera, by the wings being folded when at rest, throughout their entire length. In general these insects are *social;* the communities, however, being small. In such cases, there are *neuters*, or individuals of neither sex; but these are not destitute of wings. There are also some *solitary* Wasps (whose habits resemble those of the Fossores, whilst their general structure is more conformable to that of the Social Wasps), among which no neuters exist.—The best-known of the *Social Wasps*, such as the Common Wasp of this country, construct their nests with bits of wood, bark, &c., which they separate with their jaws and reduce to a pulp; and this pulp, when expanded and dried, forms a paper-like substance. With this are built layers of hexagonal cells, one row being joined to the under side of another. The top row is attached in some species, merely to the under side of a branch, or to the roof of a slight hollow, by which it may be in some degree protected; but in other species, the whole comb is enveloped in a covering, formed by several layers of the same paper-like substance, with one or more apertures (Fig. 387; and ANIM.

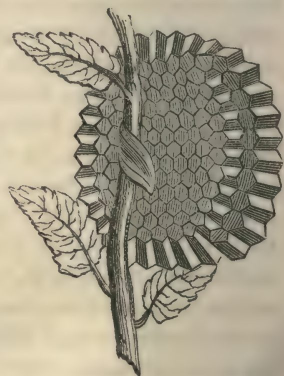


FIG. 386.—NEST OF POLISTES.

PHYSIOL. Fig. 267). Wasps feed in their perfect state upon insects, meat, fruit, &c.; and nourish their young with the juices of those substances. A Brazilian species stores up an abundant provision of honey.—The nests of the Solitary Wasps are formed of earth; they are sometimes concealed in holes of walls, in the earth, or old wood; and sometimes they are fixed to plants. The parents store them with insects or caterpillars, which they have previously wounded with their stings. These nests contain a succession of cells, in each of which a single egg is deposited.

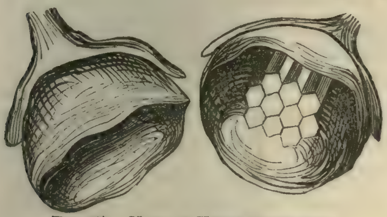


FIG. 387.—NEST OF VESPA HOLSATICA.

696. Section IV. The Hymenoptera belonging to the *Melliferous*, or honey-collecting divisions of the Aculeata, are known by the peculiar conformation of the hind-feet; of which the first joint is compressed and extended into the form of a square plate, and provided on the inside with brush-like tufts; these organs are employed for the purpose of collecting and carrying the pollen of flowers, which is destined for the nourishment of the young.—All the insects of this tribe are commonly known by the name of *Bees;* but the tribe, like that of Wasps, contains two different groups,—in one of which the species are all solitary, and there are only two kinds of individuals—males and females—in each; whilst the others mostly live in societies of greater or less extent, but are chiefly distinguished from the former by certain peculiarities in the structure of the mouth.

FIG. 388.—HIND LEG OF WORKING BEE.

697. Of the *Solitary Bees*, which constitute the family ANDRÆNIDÆ, there are many curious varieties; some of which go under the names of Mason, Carpenter, and Upholsterer Bees, from the materials on which they respectively work; the first

agglutinating bits of sand or gravel, by means of a viscid saliva, and constructing with these a regular edifice ; the next excavating

FIG. 389.—XYLOCOPA, OR CARPENTER BEE; AND NEST.

wood by means of their powerful jaws ;—and the last constructing their cells out of pieces of leaves, which they cut into the requisite form with surprising dexterity. The purpose of these operations is, in all instances, to form a series of cells ; in each of which an egg is deposited, with a supply of pollen-paste for the nutrition of the larva.

698. Of the *Social Bees*, or APIDÆ, there are two principal groups ; the first consisting of the *Humble-Bees* or *Wild-Bees ;* and the second of the *Hive-Bees.*

699. The *Bombi*, or *Humble-Bees*, of which there are many species in this country, live in curious habitations, which are sometimes excavated at a considerable depth in the ground, and sometimes built upon its surface, beneath stones, &c. The societies consist, in some species, of about fifty or sixty individuals ; in others of as many as 200 or 300. They contain three

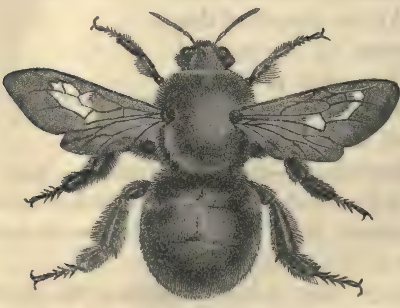


FIG. 390.—BOMBUS.

kinds of individuals,—males, females, and neuters: of these the females are the largest, and the neuters the smallest. The females alone survive the winter; and they employ the first fine days in spring to commence their nests, which they very quickly excavate, and supply with a mixture of honey and pollen for the nourishment of the first brood. This consists exclusively of *workers* or *neuters;* which, after having undergone their transformations, assist in the labours of the nest,—both by the construction of new cells, the collection of food, and the rearing of the larvæ. It is not until the autumn, that the males and females are produced. The former proceed from eggs laid by females, so much smaller than the rest, that they have been mistaken for workers. At the commencement of winter, all but the larger females die; these remain in a sort of chamber distinct from the rest, rendered warm by a carpeting of moss and grass; but without, as it would appear, any supply of food.

700. It is in the *Hive-Bees*, that the arts of construction, and the union of individuals in societies, are exhibited in the most remarkable manner. These societies contain but a single perfect female, commonly termed the Queen,—several hundred males, which are known as Drones,—and about twenty thousand Workers or Neuters. It is by the latter that all the labours of the hive,—the construction of the combs, the collection of food, and the nourishment of the larvæ,—are performed. The accompanying figures exhibit the relative sizes and aspects of these three kinds. The wax of which the comb is constructed, is secreted by the

FIG. 391.—QUEEN BEE.

FIG. 392.—DRONE BEE.

FIG. 393.—NEUTER BEE.

insects themselves, in little scales, which work out between the segments of the abdomen. These are taken up and kneaded by the jaws, and applied in the proper place. The cells are for the

reception of the eggs, of honey and of the pollen of flowers mixed with honey, into a paste known as *bee-bread.* This food is not deposited in the cells with the eggs; but is supplied to the larvæ by the workers, which tend them most assiduously. The honey is stored up for the support of the adults through the winter; a considerable proportion of the Neuters surviving, as well as the Queen, when the supply of food is sufficient. The Drones are killed at the end of the summer, by the stings of the workers, being themselves unprovided with any means of defence. The eggs are laid in the central part of each comb, which is the warmest situation; those which are to produce Drones have cells constructed for them, which are rather larger than the rest; and those from which Queens are to be reared, termed royal cells, are much larger and of different form. When so many young Bees are produced, that the hive is over-peopled, colonies are sent forth with young queens in search of another habitation. Further details on the economy of Bees have been elsewhere given (ANIM. PHYSIOL. §§ 712—716); and others will be found in a later part of this volume.

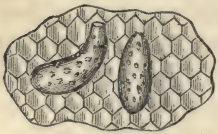


FIG. 394.—ROYAL CELL.

ORDER V.—LEPIDOPTERA.

701. This Order, characterised, as formerly stated, by the downy covering of the wings, contains some of the most beautiful forms of the whole class, as well as some of the largest. The number of species it comprehends, is probably as great as that of any other Order, except the Coleoptera; and may probably rank as about one-fifth or one-sixth of the whole class. All the insects of this Order are commonly ranked as *Butterflies*, *Moths*, and *Sphinges* or *Hawk-moths;* and whilst they are most readily distinguished from all others, there is so much general resemblance among themselves, that the difficulty of classifying

them is often considerable. The possession of scales upon their wings is not altogether peculiar to them, for they are found upon the wings and bodies of other insects; but it is only in these, that the wings are covered with such complete layers of them. The scales

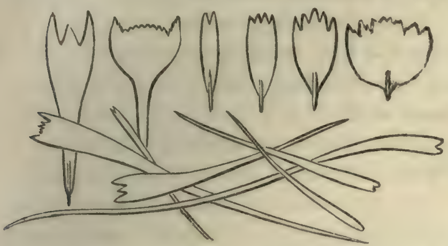


FIG. 395.—FEATHER-SCALES OF THE GOAT-MOTH.

are generally of somewhat oval form, terminating at one end in a kind of stalk, by which they are attached to the membrane of the wing; and on this they are arranged in rows, overlapping each other like tiles on a roof. They may be easily rubbed off with the finger, and the bare membrane is left, which is then seen to correspond with that of the wings of other insects. The number of scales covering the wings of the Silkworm Moth, has been estimated at about 400,000; it is entirely to these that the colours of the wings are due, which are frequently so gorgeous in this Order. In a few species, the wings are partially, or even almost entirely destitute of scales; but the structure of the mouth, and their alliance in general characters with other species, leave no doubt that they belong to this Order. Of the peculiar adaptation of the mouth of the Insects composing this Order, for *suction*, mention has been already made (§ 616); and they are therefore placed at the head of the Haustellate or Suctorial group, as the Coleoptera are at the head of the Mandibulate insects. Of their metamorphosis, also, an account has been given; and it now only remains to describe some of the peculiarities of the larvæ and pupæ of this Order.

702. The first three segments of the body, in the Lepidopterous larvæ, have each a pair of simple, short, and jointed feet; which are the rudiments of those of the perfect insect. Behind these are a variable number of temporary appendages, called *pro-legs*, which are thick, short, fleshy tubercles, armed at their extremity with a great number of minute hooks; and furnished with powerful

muscles. There are usually five pairs of these—four of them succeeding the true legs, and another proceeding from the last segment of the body. Those possessing pro-legs on nearly every segment, crawl upon all the feet at once, after the manner of the Myriapoda; but those which have only a small number of pro-legs adopt a different method. They seize fast hold of the objects on which they are stationed, with the six true legs at the fore part of the body, and then elevate the intermediate segments into an arch, until they bring the pro-legs behind close to the others; they then disengage the true feet, and retaining hold with the pro-legs, they thrust the body to its full length, and then recommence the same manœuvre, which they execute very quickly. They are called, from this circumstance, Loopers or Geometers. Many of them resemble small

FIG. 396.—CATERPILLAR AND CHRYSALIS OF MAGPIE MOTH.

FIG. 397.—1. CATERPILLAR OF SWALLOW-TAILED MOTH (*Curapteryx Sambucaria*). 2. CATERPILLAR OF PRIVET HAWK-MOTH (*Sphinx ligustri*).

pieces of stick in their forms and colours; as well as in their mode of occasionally standing fixed to twigs, by their hind legs only, for a great length of time. Such an attitude requires a great amount of muscular force; and we find that the muscular system of these Caterpillars is very complicated and highly developed (Fig. 398). It was stated by Lyonnet, who devoted many years to the study of the anatomy of the larva of the Goat-moth, that this contains 4041 distinct muscles.

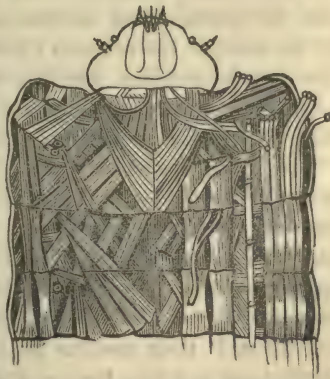


FIG. 398.—DORSAL MUSCLES OF THE ANTERIOR SEGMENTS OF THE CATERPILLAR OF *Cossus*.

703. The greater number of Caterpillars are vegetable-feeders, most of them confining themselves to the leaves of plants; and the correspondence between the development of the leaves and flowers of plants on the one hand, with that of the Caterpillars and Butterflies which are respectively to feed upon them, cannot but strike every one as a beautiful example of creative foresight.—But there are some Caterpillars, which are adapted to feed upon such flowers, as come forth early in the year; and others attack seeds, roots, and even the woody portion of the stem. Moreover, there are a few which live in this state upon animal matter, such as wool, hides, leather, and fat. Many can digest a considerable variety of alimentary materials; whilst there are others that can only find support on some one kind,—the leaves of a particular species of plant for example. The habits of Caterpillars are extremely various. Some burrow into the substance of

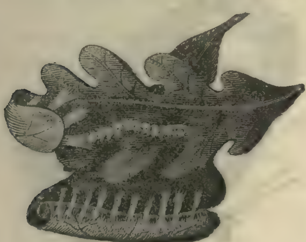


FIG. 399.—NEST OF TORTRIX.

leaves, in which they excavate galleries; others envelope themselves in the membrane of the leaf itself, which they roll together and attach by threads,—as seen in Fig. 399, representing the nest of the larva of *Tortrix viridissima* (a small nocturnal Butterfly), which is constructed upon the leaves of the Oak. Many construct cases or sheaths, either fixed or portable, by agglutinating several substances together,—as is done by the larva of the common Clothes'-Moth; and there are some that live in societies, dwelling together under a tent of silk, which they spin in common, and which serves to defend them from the inclemency of the weather.

704. The Imago, or perfect Insect, when it throws off its last envelope and comes forth into the air, of which it is henceforth to be one of the gayest inhabitants, is not altogether perfect, although capable of very soon becoming so. The wings appear at first very slightly developed, and sometimes even hang loosely at the sides; and it is not until the animal has injected their tracheæ with air,—by taking several full inspirations and then forcing it into these passages,—that they become expanded so as to serve for flight. From that period the body is supported by them, during by far the largest proportion of their active state; the legs being weak and used only

FIG. 400.—TORTOISE-SHELL BUTTERFLY JUST EMERGED FROM THE CHRYSALIS.

FIG. 401.—DANAIS PLEXIPPA.

to rest upon, and one pair being sometimes undeveloped (Fig. 401).

705. The Lepidopterous insects are divided into three

sections; which differ alike in their conformation and habits. These are,—I. The DIURNA, *Diurnal* Lepidoptera, or *Butterflies*, which may be at once distinguished by the vertical position of the wings during repose;—II. The CREPUSCULARIA, or *Twilight* Lepidoptera, commonly known as *Hawk-Moths*, in which the wings are horizontal in repose, and the antennæ thick and club-shaped;—and III. The NOCTURNA, *Nocturnal* Lepidoptera, or *Moths*, whose wings are also horizontal or inclined in repose, but whose antennæ are more slender, tapering gradually from the base to the point.

706. Section I. DIURNA.—The first section corresponds with the Linnæan genus *Papilio;* which is now, however, very much subdivided. The Butterflies are distinguished from the other Lepidoptera by the brilliancy of their colouring, and by the beauty of the under as well as the upper side of the wings. Their Caterpillars have usually sixteen feet; and their Pupæ are nearly always destitute of any silken envelope, and are attached by the tail. The Pupa of nearly every Butterfly of this group is ornamented with golden spots; from which circumstance the name Chrysalis is derived: this term ought, therefore, to be limited to the Pupa of the Butterflies; but it is now in such general use, as applied to all Pupæ, that it is undesirable so to restrict it, and the term *Aurelia* (which means in Latin what Chrysalis does in Greek) is now employed by Entomologists to designate *these* Pupæ. The antennæ of Butterflies are sometimes knobbed at their extremities, sometimes of the same thickness throughout, and sometimes taper gradually from base to point. To the genus *Vanessa*, which is distinguished by the abrupt termination of the antennæ in a short knob, belong several of

FIG. 402.—ARGYNNIS PAPHIA.

the most beautiful of the British Butterflies;—such as the Peacock (Fig. 403), the Painted Lady, the Camberwell Beauty, the Red Admiral, the Tortoise-shell, and others. The subdivisions

FIG. 403.—PEACOCK BUTTERFLY.

of this Section bear so strong a resemblance to each other in structure and habits, that it is not requisite to describe them more minutely.

707. Section II.—The CREPUSCULARIA, or *Hawk-Moths*, correspond with the Linnæan genus *Sphinx;* which derives its name

FIG. 404.—SPHINX OF THE VINE.

from the peculiar attitudes, resembling that of the sculptured Sphinx of antiquity, into which the larva sometimes throws itself (Fig. 397, [2]). Although the Lepidoptera arranged under

this division on account of their correspondence in structure, are mostly twilight-fliers, this is not the case with all; for there are some which come abroad in open daylight, and suck the juices of flowers with their long trunks, whilst the sun is brightly illumining their wings. These species are observed to be more brilliantly coloured than the rest; the body and wings in most of the Sphinges having a dull, brownish-grey aspect, like that of many Owls, whose habits are similar. The wings are more downy in appearance than those of Butterflies, as if the scales did not lie so closely upon one another. The larvæ of the Hawk-Moths have always sixteen feet; and their pupæ are either inclosed in a cocoon, or bury themselves in the earth. The perfect insects make a loud humming noise in their flight.—One of the most remarkable of this group is the *Acherontia atropos*, Death's-Head-Moth (Fig. 312), which is distinguished by the skull-like patch on the back of the thorax, as well as by the squeaking sound which it emits. In consequence of the peculiar aspect of the body, the sudden appearance of this insect in large numbers has been commonly regarded as ominous of evil. It is a great enemy to Bees, and enters their hives, devouring their honey, and alarming the inhabitants so much, that they keep aloof from it instead of attacking it, although it has no means of defence.—The *Sphinx stellatarum*, or Humming-bird Hawk-Moth, commonly known under the name of "Bee-bird," is one of the most beautiful of the diurnal species; and is remarkable for the loudness of the sound which it produces, when feeding self-poised upon its wings, by means of its long proboscis, which it inserts into the cups of even the narrowest tubular flowers. It might thus be almost regarded as the representative, in our own climes, of those feathered beauties after which it is named, that delight the eyes of the observer of Nature in tropical regions.

708. Section III. The group of NOCTURNA, or *Moths*, is by far the most extensive of the order, and includes the largest species. In their general aspect, Sphinges and Moths are somewhat alike; but they may be at once distinguished by the form of the antennæ, which taper in the latter from base to point.

Many of them have no distinct trunk; and in some species the females are almost, or altogether, without wings. Sometimes the wings can be rolled round the body; and in a few instances they fold longitudinally, like a fan. The greater part of these Lepidoptera fly by night, and their colours are usually dull. Their Caterpillars vary as to the number of their legs, from ten to sixteen; their pupæ are of rounded form, and almost always spin a cocoon. The large number of species belonging to this section, and the general similarity of their form, make their classification a matter of some difficulty. They have been divided into ten families; of which it will be sufficient here to notice the most important.

709. The first family, that of HEPIALIDÆ, contains two interesting genera, *Hepialus* and *Cossus*. The Moths of the former are commonly termed *Swifts*, from the rapidity of their flight, which takes place during the twilight; the sexes vary considerably in appearance and structure,—the male of one species, which frequents the Hop, being pure white, whilst the female is yellow, with darker markings. The male is commonly known as the *Ghost-Moth*, from his colour, and from his habit of hovering with a pendulum-like motion, over one spot (often in churchyards), where the female is concealed. The genus *Cossus* contains the *Goat-Moth*, one of the largest of British Lepidoptera; which has received its common name from the goat-like character of the strong scent emitted by the larva. This larva feeds upon the wood of willow-trees, which it perforates in every direction, and thus so greatly weakens the trees, that they are often blown down with the first strong wind. It was this larva, which was so laboriously dissected by Lyonnet (§ 702); and his researches were continued upon the pupa and imago, so as to constitute the most elaborate and complete account of the anatomy of any Insect, that has been yet given to the world.

710. The family of BOMBYCIDÆ consists of Moths allied to that of the common *Silk-worm*. The pupæ are inclosed in cocoons of pure silk, frequently of very firm texture; and they are rarely subterranean. The prevailing hues of these Moths

are grey or fawn colour; and many of the larger species have the wings ornamented with eye-like spots (Fig. 405). This

FIG. 405.—EMPEROR MOTH.

tribe contains the largest species of Lepidoptera. The *Saturnia pavonia major*, found in France, has been seen to attain the breadth of five inches across the wings; and the *Saturnia pavonia minor*, or Emperor Moth of this country (Fig. 405), attains the breadth of $3\frac{1}{2}$ inches. Many of this genus are remarkable for the

FIG. 406.—SATURNIA PROMETHEA.

contrivances they adopt for security in the Chrysalis state; and among the most so is the *Saturnia promethea* (Fig. 406), an

American species, which, previously to spinning, draws together the sides of a leaf (within which it afterwards forms its cocoon), and fastens its stalk to the stem by a strong silken web (Fig. 407). The genus *Bombyx* is one of great interest and importance, as containing the *Bombyx mori*, whose larva furnishes all our silk; as well as many other species. Of these, some much resemble a bundle of dead leaves, both in colour and form, when their wings are closed; such is the *Bombyx quercifolia*, or Oak-leaf Moth (Fig. 408). The Caterpillars of another species of Bombyx are remarkable for their curious habits. They live in societies on the leaves of the oak; and spin, when young, a kind of silken tent, divided within into cells. They may be seen to issue from it in the evening in a procession, — one of them, which seems to act as a guide, advancing at the head,—two then following,—then three,—then four,—and so on, each rank containing one more than the preceding one. Hence they have been called *processionary* caterpillars. Each spins a separate cocoon; but they are united in regular apposition, being laid side by side against each other.

FIG. 407.—CATERPILLAR, LEAF-COCOON, AND CHRYSALIS OF THE PROMETHEUS MOTH.

FIG. 408.—BOMBYX QUERCIFOLIA.

711. The family NOCTUIDÆ contains a great proportion of

the larger sombre-coloured night-flying Lepidopterous insects; and contains 400 British species, which bear a very strong resemblance to each other.—The family GEOMETRIDÆ, so named from the peculiar mode of progression of its Caterpillars (§ 702), is nearly allied to the preceding; but the Moths it includes are less exclusively nocturnal, and are more brightly coloured. To this family belongs the common *Magpie Moth* (Fig. 409), whose larva and pupa have been already represented (Fig. 396); also the *Swallow-tailed Moth*, and many other well-known species.—The TORTRICIDÆ constitute a numerous group, composed of minute and usually dull-coloured Moths, whose larvæ are extremely destructive to vegetation. One of these, known as the Codling Moth, is one of the most destructive enemies to the Apple crops of this country; laying its eggs in the eyes of the newly-formed fruit, within which the larva feeds, its presence being only indicated by the premature falling off of the fruit.—Another species does great damage to our apricot trees in the early spring, by tying the young shoots together with threads, so firmly that their growth is stopped, and by devouring the young blossom-buds. Another species (Fig. 399) feeds upon the Oak, which in certain years it totally strips of its foliage; its numbers

FIG. 409.—PHALÆNA GROSSULARIATA.

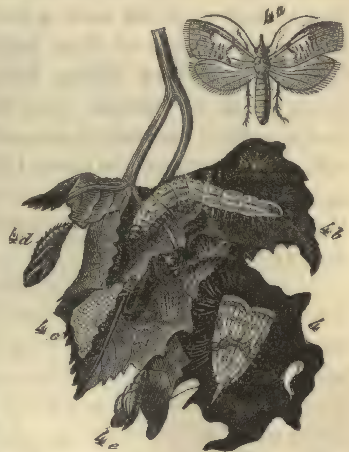


FIG. 410.—PYRALIS VITIS.
4, Male; 4 *a*, Female; 4 *b*, Caterpillar; 4 *c*, Eggs; 4 *d*, 4 *e*, Pupæ.

being so great, that when the branches of that tree are sharply beaten, a complete shower of these moths is dislodged. And another commits great havoc in our gardens, by eating the young leaves and buds of the roses; the caterpillar feeding within the bud, from which, when disturbed, it lets itself down by a thread. One of the most destructive insects of this family is the *Tortrix vitana* (the *Pyrale* of French Entomologists); whose larvæ commit extensive ravages in the Vineyards of some parts of France, where they occasionally appear in very large numbers, devouring and tying together the leaves, and preventing the development of the grapes, by surrounding them with the silken threads of which they make their cocoons (Fig. 410).

712. The family TINEIDÆ contains those little Moths, commonly termed *Clothes'-Moths*, whose larvæ are so injurious to woollen stuffs of every kind, as well as to furs, skins, feathers, and other objects of natural history, upon which their voracity is exercised. They use the same materials also for the construction of their moveable cases or sheaths; which they enlarge with the increasing size of their bodies, both by adding to their extremities, and by slitting them along and inserting a new piece, so as to increase their diameter. In these tubes they undergo their metamorphoses, after closing the orifice with silk.—The larvæ of the genus *Galleria* infest Bee-hives, feeding upon honey, forming galleries in the honeycomb, and enveloping the bees in their silken webs, sometimes to such an extent as to destroy the community.

713. The FISSIPENNÆ, or *Plumed Moths* (Fig. 304) constitute a small group, distinguished from all other Lepidoptera by the singular division of the wing into branches or rays, of which each pair has from two to six; these are most beautifully fringed at their edges, and much resemble the feathers of Birds. They are composed of the nerves alone, without any intervening membrane; this last seeming to have been transformed into the fringe. The Plumed Moths are of small size; some of them are diurnal and brightly-coloured; others are twilight-fliers, and of a duller aspect. Some species have the power of folding up the wings like a fan; so that, when closed, they present the appearance of a single broad ray.

714. This is probably the place in which the small Order STREPSIPTERA should be introduced; although the insects composing it depart so widely from the general type, that it is difficult to say to what orders they are most nearly allied. They are few in number; and are parasitic in their larva state upon other insects, especially the solitary Bees belonging to the family Andrænidæ. The name of the Order, which means "twisted wings," has reference to certain curious appendages, that look as if they had been twisted, which are seen in front of the wings; these appendages are attached to the second segment of the thorax, whilst the wings (of which there is only one pair) proceed from the third; hence they are to be regarded as the altered rudiments of the *anterior* pair of wings, in the same manner as the *balancers* of the Diptera are to be considered as the rudiments of the *posterior* (§ 724). The most remarkable feature in the organisation of these insects, is the absence of any opening at the mouth; although it is furnished with appendages in some degree resembling those of the Lepidoptera. The eyes are large and prominent, being mounted on footstalks as in many Crustacea. The antennæ are of singular form, being usually furnished with an internal branch or projection nearly as long as the antennæ itself. The wings are large, and folded in a fan-like manner; when in motion they make a buzzing sound, which is considerable in proportion to the size of the animal. The third segment of the thorax, to which they are attached, is developed

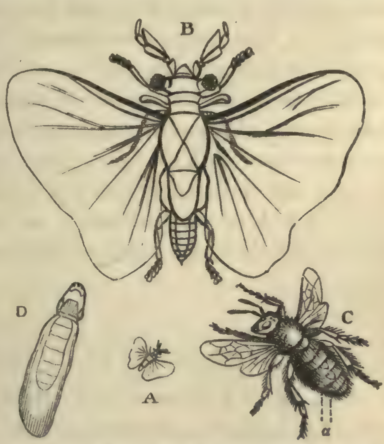


FIG. 411.—A, Stylops Dalii, nat. size; B, magnified; C, Andrena, with the heads of two of its larvæ exserted between the abdominal rings, *a*; D, larva extracted and magnified.

to an extraordinary size in proportion to the rest of the animal. The larvæ appear to feed upon the fatty matter in the bodies of the Bees and Wasps, on which they are found, without injuring their vital parts; and their production does not seem to cause the death of the animals they infest. When full grown, their heads may be seen projecting between the segments of the abdomen of the Bee (Fig. 411, *a*). Here, too, they undergo their metamorphosis into the pupa state; remaining still inclosed in the larva-skin, and bursting through both the larva and pupa cases, to make their way forth as perfect insects. No distinct mouth has been discovered in the larva, and its mode of obtaining nourishment is unknown. Many points in the economy of these singular insects are still uncertain; especially all that concerns their reproduction. All the specimens yet discovered appear to be males; and it has not been yet ascertained when and how the eggs are laid, or at what stage in the growth of the animals infested by them, the parasites first make their appearance.

Order VI.—HOMOPTERA.

715. The Insects of this Order are distinguished from all others which have, like them, the mouth adapted for suction, by possessing two pairs of wings, usually composed of a firm membrane, and not covered by scales; and by having the anterior pair, whatever may be their consistence, of the same substance throughout, and roof-like when folded. They present many curious anomalies both in structure and habit; so that it is difficult to assign any general character that shall include them all. It is in the structure of the mouth that there is the greatest agreement; this is adapted for suction, the tongue being elongated and channelled like a gutter, and being surrounded by delicate lancet-like organs, with which the tissues of plants are pierced. All the Insects of this group subsist on vegetable juices; and some of them, from the amount of damage they commit, are very injurious to the cultivator. Some of the females are furnished with an ovipositor, provided with several

toothed saws; and with this they make incisions into the leaves and stems of plants. This Order may be divided into sections, like the Coleoptera, according to the number of joints in the tarsi. These sections are only three in number: in the first, TRIMERA, the tarsi are *three*-jointed; in the second, DIMERA, they are but *two*-jointed; and in the third, MONOMERA, they have but *one* joint.

716. Section I. TRIMERA. The three-jointed division of the Homoptera includes three families, the CICADIDÆ, or *Cicadas*, the CERCOPIDÆ, or *Froth-hoppers*, and the FULGORIDÆ, or *Lantern-flies*.—The CICADIDÆ are the largest of the Order; one species measuring between six and seven inches in the expanse of its wings. They are nearly all inhabitants of tropical or the warmer temperate regions; only one small species having been found in this country. They have large transparent wings, but are not very active in their habits; being generally found upon trees or shrubs, whose juices they suck. The female makes a succession of slits in the small twigs with her ovipositor, and deposits her eggs in these; the young larvæ soon quit their birth-place, however, and descend to the ground, where they increase in size and become pupæ. It is a species of *Cicada* inhabiting a kind of Ash, which, by puncturing it, causes it to discharge the sweet, slightly purgative, substance, that is known as Manna.—Of the peculiar sound-producing powers of the Cicadidæ, an account has been elsewhere given (ANIM. PHYSIOL. § 679). The ancient Greeks used the Pupæ and perfect insects as articles of food.

FIG. 412.—CICADA.

717. The FULGORIDÆ bear a general resemblance to the Cicadidæ, but are generally destitute of organs for producing

sound, and have the legs more adapted for leaping. Many of them are distinguished by a curious prolongation of the forehead, which sometimes equals the rest of the body in size. The shape of this projection varies extremely in the different species, which are numerous in many tropical regions. It is in it, that the luminous property of the *Lantern-fly* (Fig. 413) is said to exist; but the luminosity of this insect,—of which one species is a native of Guiana, and another of China,—is doubted by many naturalists, the evidence in regard to it not being sufficient. If it really exists, it is only at particular seasons. The Lantern-fly of Guiana seems to be an exception to the general rule, with respect to the absence of sound-producing powers in this Order; for it produces, from sun-set to sun-rise, a loud sound which has been compared with that of a razor-grinder at work.

FIG. 413.—FULGORA LANTERNARIA.

718. The family CERCOPIDÆ consists of insects of small size; many of which are remarkable for the grotesqueness of the forms they assume. Several species are inhabitants of this country, and are known under the name of *Frog-hoppers*, from their leaping powers; or of *Froth-hoppers*, from their peculiar frothy secretion; or of *Cuckoo-spits*, from the supposed origin of this fluid. The most singular forms, however, are confined to the tropics; and examples of them are presented in the accompanying figures of two Brazilian species, whose curious appendages result from an extraordinary development of the first segment of the thorax. The insects of this family are often beautifully varied in their colours; they are constantly found upon plants, upon the juices

FIG. 414.—*a*, Bocydium globulare; *b*, B. cruciatum.

of which they subsist in all their stages; and some of them are employed by certain species of Ants, for the same purposes as the Aphides (§§ 694 and 719). The *Aphrophora spumaria* is one of the best known British species; its larva and pupa, resembling the perfect insect in almost every respect save the absence of wings, are found beneath a frothy exudation,— especially upon willow-trees; and the exudation is sometimes so abundant, from the large number of these animals, that persons walking beneath are wetted by the continual dropping of the fluid. A species nearly allied to this, inhabiting Madagascar, discharges a clear instead of a frothy fluid; and this in such quantities, that it falls to the ground in the middle of the day, when the heat is the greatest, in a continual shower.

FIG. 415.—APHROPHORA SPUMARIA; *a*, imago; *b*, frothy secretion; *c*, pupa.

719. Section II. DIMERA. This section entirely consists of minute insects; of which the most remarkable family is that of APHIDÆ, or *Plant-Lice*. These live in great numbers upon the surface of plants of almost every description, and suck the juices, by means of their proboscis, from the young shoots, leaves, stems, and even roots. They greatly weaken its vigour, and often distort young shoots and leaves; some species cause little gall-like excrescences by the irritation they produce. From two horn-like processes at the posterior part of their bodies, a saccharine secretion exudes, of which Ants are very fond (§ 694); and it is either this fluid dropped on the adjacent leaves, or the extravasated sap flowing from the wounds made by the insects, which is known under the name of *honey-dew*. In many of the species of this family, a large proportion of the individuals never acquire wings; in which case the Pupa is not to be distinguished from the Larva or Imago; whilst at certain parts of the year, other individuals of the same species, and of both sexes, acquire wings. The wingless Aphides, which may be seen in the spring and early summer, are all females capable of producing

fertile eggs; and from these are reared the winged males and females, which are seen later in the season. Their rapidity of production is enormous; nine generations having been produced within three months, and each generation averaging 100 individuals. Hence it may be calculated that, from a single Aphis, 10,000 *million millions* may be generated in that short period. It is not surprising, then, that an immense amount of damage should be done by them, notwithstanding their very small size. Many of the *blights* so injurious to the gardener and the agriculturist, consist really of Aphides; although from the minuteness of the insects themselves, they frequently escape observation. The *Aphis Rosæ*, or Rose Louse, is one of those best known to the gardener; whilst the one most destructive to the property of the cultivator on a larger scale is the *Aphis Humuli*, or Hop Fly. Of the extent of its influence on the production of that vegetable, some idea may be formed from the fact, that the *duty* paid to the English government on its growth, has varied from 468,000*l*, to 15,400*l*. in different years, almost entirely from the absence of this insect in the former case, and its presence in the latter; and the difference in the actual value of the crop is, of course, far greater.

FIG. 416.—APHIS ROSÆ.

720. Section III. MONOMERA. The third section contains but one family, that of COCCIDÆ, sometimes called *Scale Insects*. These, although ordinarily of very small size, are amongst the most injurious to vegetation of the whole tribe. Like the last, they are remarkable for their powers of propagation; and when they once gain possession of a plant or young tree, its death is almost certain,—the minute size of the larvæ rendering it almost impossible to exterminate them. They furnish, however, some very important products. The bodies of many species are deeply coloured through their whole substance, and yield dyes of great value; the richness of which seems to depend upon the nature of the plant on which they feed. The *Coccus* of the ancients was a native of the Levant; but that which furnishes the *Cochineal* so highly valued at the present time, was originally confined to Mexico, where it feeds on the plants of the *Cactus*

tribe ; it has been introduced, however, along with its proper food, into Spain and Algiers, as well as into the hothouses of this country. About 800,000 lbs. weight of Cochineal are annually brought to Europe ; each pound of which contains about 70,000 insects. The *Lac* of the East Indies, which is extensively employed in the composition of varnishes, the making of sealing-wax, &c., is the product of another species of Coccus. The species which inhabit our own country, are important rather on account of the damage they commit, than the benefit they afford to Man. The bark of many of our trees often appears warty, by reason of a great number of small oval or rounded bodies, like a shield or scale, which are fixed to them, and in which no external traces of the insect are to be observed. These, however, are larvæ belonging to the tribe in question. Some of them are females ; others young males, which are similar to them in form. At a subsequent period, they all undergo singular transformations. The males fix themselves to the plant, and pass into the pupa state, in which they remain completely at rest ; and at last emerge as winged insects,—coming out of their cocoons backwards, with the wings extended flatly over their heads. The females, on the other hand, remain attached to the plant, and increase in size, in consequence of the development of a large number of eggs in their interior ; but they undergo scarcely any other change. The eggs are deposited between the lower side of the body, and the surface to which it is attached ; the latter having been previously covered with a sort of cottony secretion. The parent then dies, and her body dries up and becomes a solid cocoon, which covers the eggs. Here the eggs are hatched ; and the young larvæ, which are at first active in their habits, quit their envelope, and ascend to the extremities of the branches ; there they affix themselves by their sucking-beak, gradually increase in size, and lose their activity. In this condition they pass the whole winter ; and it is not until the succeeding spring, that the characters of the sexes, which are henceforth to be so distinct, begin to show themselves.

Order VII.—HETEROPTERA.

721. These Insects bear a close general resemblance to those of the last Order; but are distinguished by the characters of the anterior pair of wings, which are tough at their bases and membranous only towards their points, and which fold nearly horizontally, partly overlapping each other. The mouth is formed nearly on the same plan as that of the Homoptera; being adapted solely for suction. By far the greater number of the Insects of this Order feed, like the preceding, upon the juices of plants; but some of them prey upon other and weaker Insects; and a few species (of which the numbers, however, sometimes multiply to a great extent) suck the juices of larger animals. The majority of this Order are found in tropical climates; and the species that inhabit those regions, are mostly ornamented with a great variety of beautiful colours and markings, which often vie with those of the most splendid of the Beetle tribes. Many species, however, are of aquatic habits; and these are all of an obscure or black colour. Nearly all the terrestrial species have the power of emitting, when they are suddenly alarmed or touched, a powerful odour; which is of a pleasing character in some species, but which in others (as the common Bed-bug) is very disgusting. Many of them seem to eject a poisonous fluid into the wound which they make for the purpose of suction. In some species, the wings are altogether undeveloped; or the upper pair is wanting. The insects of this Order continue active, and require food, during all the stages of their existence. They may be divided into two sections, distinguished by their residence, and by the modifications of their structure in accordance

Fig. 417.—Pentatoma.

with it ;—the GEOCORISÆ, or *Land-Bugs;*—and the HYDROCORISÆ, or *Water-Bugs.*

722. Section I. GEOCORISÆ. This section contains a large number of families ; nearly all of which, however, bear a strong general resemblance to that which includes the common Bugs,—the CIMICIDÆ. Some of the tropical species attain considerable size, being described as of the bulk of a Cockchafer ; and they are much dreaded by the inhabitants of the regions they infest. Many of the Geocorisæ, however, are vegetable-feeders ; and it is among these, that the most brilliant colours are exhibited.

FIG. 418.—HALYS.

FIG. 419.—CIMEX LECTULA'RIUS.

The common *Cimex lectularius*, or Bed-bug, and its allies, never possess wings.—There is a curious group of very long-legged insects, which, though placed in this section, leads to the next ; this is the family HYDROMETRIDÆ, some species of which may be met with on almost every pond or stream, skimming along the surface, and turning rapidly about, with the greatest ease and velocity. The form of the body strongly resembles that of a London wherry ; the hind feet conjointly act as a rudder ; and the motion is given by the two middle feet, which do not, however, dip into the water, but merely brush along its surface. The body is clothed on the under side with a fine coating of hairs, forming a sort of plush ; which is evidently serviceable in preventing it from coming in contact with the water.

723. Section II. Of the HYDROCORISÆ, or true *Water-*

Bugs, there are two families only. The NOTONECTIDÆ, or *Boat-flies*, live almost entirely in the water, where they feed upon other aquatic insects; these they seize by means of their fore-legs. The legs of the hinder pair have a fringe of bristles along their edge; by which the surface, with which they strike the water in swimming, is greatly increased. Their general form is extremely well adapted for rapid progression in water; and it is from the peculiar aspect and movement of the body, that they have received the name of *boat-flies* or *water-boatmen*. The insects of this family swim on their backs; and the arrangement of all their organs has reference to this position. When stationary at the surface of the water, as is much their custom in calm hot weather, they very quickly obtain intelligence of the approach of danger, by means of their eyes, which are so placed that they are able to see both above and below the surface; and then, by a single stroke of their paddles, which are commonly stretched out at full length, they descend out of sight. Their motions are very quick in the element they are chiefly formed to inhabit; whilst on land they are scarcely able to walk. They can fly well; but they rarely exercise this power. The larva and pupa only differ from the imago in their smaller size, and in the deficiency of wings. When they descend into the water, the Notonectidæ carry down a supply of air for respiration, in a hollow which exists beneath the wings, when these are folded together.—The NEPIDÆ, or *Water-Scorpions*, receive their name from the scorpion-like form of their fore-legs, which are efficient instruments for seizing their prey. They are in most respects similar in structure and habits to the insects of the preceding family; but their motions are much slower, their legs not being so advantageously formed for swimming. The species represented in the accompanying figure is a very common inhabitant of our ponds.

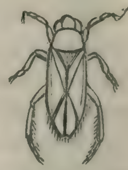


FIG. 420. — NOTONECTA.

FIG. 421. — NEPA CINEREA.

Order VIII.—DIPTERA.

724. The *two-winged* insects constitute one of the most extensive Orders in the whole Class, not only in regard to the number of distinct species, but also from the occasional excessive multiplication of individuals of the same species. Many of them, also, have been constant attendants upon Man in all ages. They do not attract attention, however, from their size, for there are few that exceed an inch in length; nor is it on account of their beauty, for the majority of them are of dull colours; their forms, too, are rarely elegant; and of the habits and metamorphoses of a large proportion of them, very little is known. They owe the notice they have attracted, chiefly to the habits of certain species; which affect Man and the Domestic Animals, in various ways, both in their perfect and early states. However annoying these may be, it must not be forgotten, that other Diptera are of extreme service, in cleansing the surface of the earth of vegetable and animal impurities; and the carcass that is full of maggots would be much more prejudicial in its decomposition, than it is when principally eaten up by these voracious creatures. The mouth in the insects of this order is formed for suction, as already described (§ 616); but there are considerable varieties in the mode in which this is accomplished. Behind the wings are found a pair of moveable slender bodies, termed *halteres*, or balancers; these are probably the representatives of the second pair of wings. They are kept in continual motion, and are usually present even when the true wings are not developed. The Diptera all undergo a complete metamorphosis, as far as respects the comparative structure of the Larva and the perfect Insect; the former being generally cylindrical footless grubs, with no representatives of legs, except in a few species. But in many there is no proper transformation into the Pupa state; the skin of the larva not being thrown off, but hardening and contracting, so as to form a kind of cocoon. Within this, the body of

the larva is found, at first apparently but little altered, except that it has become detached from the skin, to the inside of which the organs peculiar to the larva, such as the parts of the mouth, remain adherent. Shortly afterwards, the inclosed being assumes the form of a soft and gelatinous mass, in which none of the parts of the future insect remain visible; some days afterwards, however, these organs become distinct, and the insect has then assumed the real state of pupa, though without having yet thrown off its larva skin. When ready to escape, it scales off the anterior end of its case, like a cap. Many larvæ, however, do throw off their skins when assuming the perfect state, and some form a regular cocoon. The duration of life in the perfect state is usually very short.

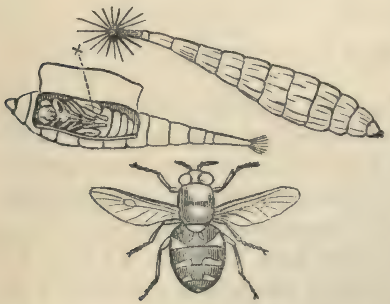


FIG. 422.—LARVA, PUPA, AND IMAGO OF STRATIOMYS CHAMÆLEON.

725. In subdividing this Order, we first separate from it a small but remarkable group, which forms the transition to the more aberrant orders of the class, especially the Aphaniptera. Some of them are entirely destitute of wings; and yet in their general structure they correspond with the Diptera. They are distinguished from all other insects by their curious mode of reproduction. Not only are the eggs hatched within the body of the parent, but the Larvæ are retained there until they have been transformed into Pupæ, in which state they come forth to the world. Hence this section has received the name of PUPIPARA. It contains two families, all the species of which are parasitic. The HIPPOBOSCIDÆ, sometimes called *Forest Flies*, are of small size, covered with bristles, and frequently destitute of wings. They are known by the French under the name of Spider-Flies. They reside upon quadrupeds and birds, running with great agility, and often sideways, burying themselves

amongst the hair or feathers. That which is parasitic on Sheep is known as the *Tick*. One minute species infests the Hive-Bee; and this is remarkable, not only for being destitute of wings, but of eyes also. In the other family, that of NYCTERIBIIDÆ, the general form still more nearly approaches that of Spiders. The group contains but a small number of species, all of which are parasitic upon Bats, and are termed Bat-Lice.

726. The remaining Diptera, constituting by far the larger proportion of the class, may be subdivided into four sections. In the first, NEMOCERA, the antennæ are composed of six joints; whilst in all the remainder, the antennæ are short, not having more than three distinct joints. In the second, NOTACANTHA, the last division of the antennæ is really composed of two; the proboscis does not project much from the mouth, and is furnished with only two lancets. In the third, TANYSTOMA, the antennæ have really only three joints, the last being usually terminated by a seta or bristle. And in the fourth, ATHERICERA, the antennæ are only two- or three-jointed, and the proboscis is capable of being withdrawn into the mouth.

727. Section I. NEMOCERA. To this division belong the two families of CULICIDÆ and TIPULIDÆ; the former known as the

FIG. 423.—CULEX PIPIENS, female, natural size and magnified, with head of male.

Gnat tribe, the latter as the *Harry Long-legs*. Both are remarkable for their beautifully-tufted antennæ; but the former are distinguished by the length of the proboscis. Gnats are well known to abound chiefly in damp situations; the reason being, that their larvæ are inhabitants of the water. In this state they are very active, swimming with great agility, and often descending; but coming to the surface to breathe, which

they do head downwards, the respiratory orifice being at the end of a very prolonged spiracle arising from the end of the abdomen. When the final transformation occurs, the skin of the pupa, which is being cast off, serves as a kind of raft, which prevents the perfect insect from being immersed in water, and thus wetting its wings. The *Mosquitoes*, which infest many countries, especially in warm latitudes, or during the brief but hot summers of some colder ones, differ but little from the common Gnats. They sometimes appear in such swarms, especially in marshy districts, that they can be only kept off by fire. Their rapid multiplication is easily understood, when it is known that their whole series of metamorphoses only occupies three or four weeks in summer, so that there may be several generations produced in the course of one season; and that each female lays several hundred eggs.—The TIPULIDÆ also have feathered antennæ, but their proboscis is very short. Some of them very strongly resemble Gnats, both in the larva and perfect states; such are the *Midges*, of which one species is represented in Fig. 424. In another group, there is a strong resemblance to the Cynipidæ, or Gall-flies; both in their minute size, veinless wings, and mode of life. Their larvæ are terrestrial, and are very commonly developed within a sort of *gall*, produced by the puncture made by the parent in the tissues of plants, when depositing its eggs. Some species make their puncture in the young sprigs, others in the leaves, and others in the flowers; and there are several which are extremely injurious both to the Gardener and the Agriculturist. Thus the Wheat crops of this country are often seriously injured by the *Cecidomyia Tritici*; the eggs of which are deposited by the female in the centre of the corolla, where the larvæ are hatched; and it is probably by devouring the pollen, that they are most injurious to the plant. Another species,

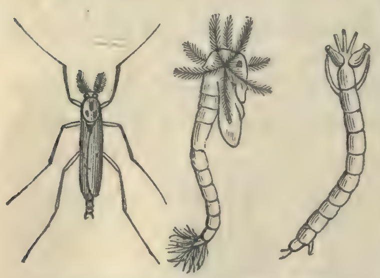


FIG. 424.—CHIRONOMUS, with its Pupa and Larva, magnified.

Cattle

C. destructor, is known in America under the name of the Hessian Fly; this attacks the lower part of the stem of the wheat. The

FIG. 425.—CECIDOMYIA DESTRUCTOR, and C. TRITICI, with the Larvæ of the latter feeding in wheat flowers, magnified.

proper *Tipulæ*, or *Harry Long-legs*, are the largest species of the family. Their larvæ generally live in the earth, in the rotten parts of trees, &c., and many of them do great mischief by feeding upon the roots of grass and corn.

728. Section II. NOTACANTHA. The second Section of the Diptera contains three families, STRATIOMIDÆ, BERIDÆ, and CŒNOMYIDÆ, which do not attract much attention, although some of the species contained in them are very abundant. They are mostly small but gaily-coloured insects; and are most numerous in moist situations, in which the larvæ are generally produced. Some of the larvæ, as that of *Stratiomys Chamæleon* (Fig. 422), are completely aquatic; and respire, like the larvæ of the Gnats, by extending their tails to the surface, the spiracle or breathing-pore being in that situation. They mostly feed upon vegetable, rather than upon animal, juices.

729. Section III. TANYSTOMA. The insects composing the third section have usually a more perfect mouth, than those of the other divisions; and they are also remarkable for the structure of the head of the larvæ, which possess two claw-like appendages, by which they attach themselves to the substances that afford them support. Many of the perfect insects are eminently carnivorous or insectivorous; as are also some of the larvæ. There is a genuine metamorphosis in this group; the larva-skin being cast off at the entrance of the animals into the pupa-state. In this state they much resemble the perfect insect; the limbs being inclosed in distinct sheaths, and folded on the breast.

The perfect Insect escapes from the pupa-state by means of a slit along the back. To this group belongs the family TABANIDÆ, or *Gad-fly tribe;* which comprises some of the largest Dipterous insects, and which is pre-eminently distinguished for the tormenting powers which different species possess. They pierce the skins and suck the blood of various Quadrupeds, both wild and domesticated; and do not spare Man himself. They chiefly abound in woods and pastures; and the buzzing noise which they make, has obtained for them the designation of "the breeze." The insect of which Bruce has spoken, in his Travels in Africa, under the name of *Zimb,* is probably a species of this family. He describes it as attacking cattle in so dreadful a manner, that, unless immediately driven to the sands, they forsake their food, and run wildly about the plains, dreading even its very sound, until they die, worn out with fatigue, fright, and hunger. The Camel, and even the thick-skinned Elephant and Rhinoceros, are said to be subject to this enemy.

FIG. 426.—TABANUS BOVINUS.

730. The family BOMBYLIIDÆ are distinguished by their very long proboscis, with which they suck the nectar from flowers. They fly with great rapidity, and hover over flowers without settling; making at the same time a loud buzzing noise with their wings. Some of them have a remarkably Bee-like form. The family ANTHRACIDÆ, which is nearly related to the preceding, is chiefly composed of exotic species, which are generally large or of moderate size, often covered with hair, and beautifully coloured. They fly in the sunshine with great agility; and subsist, like

FIG. 427.—BOMBYLIUS.

the preceding, upon the juices of flowers. In general the proboscis is comparatively short; but in a few instances, as in the *Nemestrina longirostris*, it is of extraordinary length (Fig. 321). This section also contains several other families of less interest and importance; among them we may mention the ASILIDÆ, which live by rapine, seizing Flies, Tipulæ, Humble-Bees, and even Wasps, and sucking their juices.

731. Section IV. ATHERICERA. The Dipterous insects of the fourth tribe are principally vegetable-feeders in their perfect state, only a few being carnivorous or insectivorous; but their larvæ are generally extremely voracious, and will devour almost any kind of soft animal matter. This section includes the *Flies* strictly so called, the *Bot-flies*, and many other tribes.—The first family, that of SYRPHIDÆ, bears an extremely close resemblance to the Humble-Bees and Wasps, in the nests of which some species among them deposit their eggs; this resemblance is evident in the accompanying figure, which represents the *Eristalis*, or Drone-fly (A), and the *Anthophora retusa*, or Spring Wild-Bee (B), two insects which differ entirely in their habits,—the former being the very personification of luxurious idleness, doing nothing but sip the nectar from the brightest flowers and bask in the sunshine on the leaves,—whilst the latter toils all day long, either in the construction of the nest, or in provisioning it with pollen paste. The wisdom of the Creator has provided the insects of the former group, as a check upon the too great increase of the latter; for the larvæ of the Syrphidæ, when hatched in the nests of the Bees, destroy *their* larvæ, and live at their expense. Some species restrain, in a similar manner, the excessive multiplication of the Aphides. The perfect insects feed almost solely upon flowers, preferring those of the Compositæ; and they delight to hover immoveably over certain spots, to which they will return,

FIG. 428.—DRONE-FLY AND SPRING WILD-BEE.

if disturbed, a considerable number of times. Above a hundred species inhabit Britain. In a few of them the larvæ are aquatic, and the posterior part of the body is prolonged into a respiratory tube, whence they have received the name of "rat-tailed" larvæ.

732. The form and habits of the family MUSCIDÆ, or *Fly tribe*, are generally known. The family is an extremely numerous one, above 1700 species having been recorded as existing in Europe, of which about half are natives of this country; and there are probably at least as many more, which have not been described. The strong general resemblance which exists among all the species, together with their small size, makes it difficult to discriminate them readily. The larvæ of these insects, commonly known as *maggots*, are soft, worm-like, footless grubs, possessing on the head a couple of retractile hooks, by which they can cling to the substances on which they feed. They devour various substances, both animal and vegetable, living, recently dead, or far advanced in putrefaction. The eggs are deposited by the female (as in other instances) in the neighbourhood, or in the very substance, of the food which is adapted for the support of the larva, however little this may be to its own liking. Some of these larvæ are remarkable for their leaping powers,—whence they are commonly termed "hoppers." This is especially the case with the larva of the *Piophila casea*, or Cheese-hopper; whose mode of springing into the air is very curious. When preparing to leap, it first raises itself on its tail; in which position it is enabled to balance itself, by means of some prominent tubercles on the last segment of the body. It then bends itself into a circle; and having brought the head towards the tail, it stretches out the two hooks of the mouth, fixing them into two cavities at the other extremity of the body.

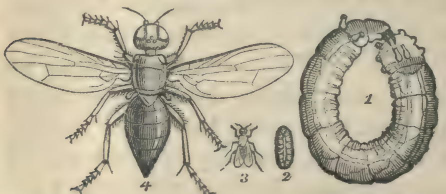


FIG. 429.—1. The CHEESE-HOPPER preparing to spring.—2. Natural size of the Larva.—3, 4. The Fly to which it is transformed: natural size and magnified.

It then contracts the body from a circular to an oblong figure; the contraction extending in a manner to every part of the body. It now suddenly lets go its hold, and straightens the body, with such violence, that the noise produced by its hooks is very perceptible. The height of the leap is often from twenty to thirty times the length of the body; exhibiting an energy of motion, which is particularly remarkable in the soft Larva of an Insect. A Viper, if endowed with similar powers, would throw itself nearly a hundred feet from the ground. The learned Swammerdam, who devoted much attention to the anatomy and habits of this creature, observes—"Now let the sharpest geniuses, and men of the greatest penetration and learning, judge if a creature, on the fabric of which there plainly appears so much art, order, contrivance, and wisdom, nay, in which is seen the hand itself of the Omniscient God, could possibly be the production of chance or rottenness." This observation refers to the idea formerly entertained almost universally, that the Maggots, which make their appearance in the midst of decomposing matter, are the results or products of that decomposition. Experiments devised for the purpose, however, have clearly shown, that there is here no exception to the general rule; for that, if the parent Insects be carefully excluded, no maggots will make their appearance in a decomposing mass of any description.—Of the voracity of the larvæ, and the rapidity with which they undergo their transformations and propagate their kind, some idea may be formed from the estimate of Linnæus,—that three Flesh-flies and their progeny would devour the carcass of a dead Horse more speedily than a Lion would do. If this estimate is at all exaggerated, it is probably not much so. Hence we see the vast importance of these Insects in the economy of Nature; for they are called into existence just in proportion to the demand for them,—the eggs of the parent not being developed, unless they are deposited in a fit situation, so that the number of individuals will not be increased unless there is matter for them to feed on,—whilst, on the other hand, the rapidity of the growth and metamorphoses of these Insects is greatly increased, by the warmth that promotes the decomposition of the substances, which they are destined to remove.

733. The Œstridæ, or *Bot-flies*, are a family very remarkable in regard to their structure and habits. The perfect insects resemble large Meat-flies in form, are very hairy, and have these hairs coloured in rings, like Humble Bees; but they are seldom seen, the duration of their lives being very short in this condition.

Fig. 430.—Œstrus and Larva.

Their chief peculiarity consists in the absence of any proper mouth in the Imago (in which respect there is an analogy with the Strepsiptera, § 714), and in the peculiar habitation of the Larva. This is always found in living animals,—its situation, however, varying with the species; and almost every herbivorous animal having one or more peculiar to it. The egg is, in some cases, deposited by the parent in situations where the larva may burrow into the flesh; there it occasions inflammatory tumors, the fluids contained in which afford it nourishment. These have an evident analogy, therefore, to the Cynipidæ, which produce Vegetable galls. In other instances, the eggs or larvæ, existing upon spots which the animal is in the habit of licking, are conveyed by the tongue into the mouth, whence they pass into the stomach. There they remain until full-grown; and then they quit the body (as do also those which inhabit the flesh), and fall to the ground, beneath the surface of which they undergo their transformations. The larvæ of one species, which inhabits the Sheep, are found in the frontal sinuses of the skull. Man is subject to the attacks of one or more species; which do not, however, inhabit this country.

Division II.—APTEROUS INSECTS.

734. Besides the foregoing Orders, we must include three others in the Class of Insects, on account of their correspondence with it in general structure; although they present only one, or even neither, of the two characters which have been stated to be its peculiar distinctions,—namely, the presence of wings in the perfect state,—and the metamorphosis.

Order IX.—APHANIPTERA.

735. Of the three Apterous orders, this one undoubtedly approaches nearest to the true Insects; for we find in it a metamorphosis, and even rudiments of wings; whilst the structure of the mouth most nearly approaches that of the Diptera. The *Fleas* and their allies, which constitute this order, resemble the Diptera also in their suctorial habits; and feed exclusively upon animal juices. Their larvæ come forth from the egg in the state of minute worms, possessing considerable activity, and feeding upon animal matter, in the midst of which the eggs were deposited by the parent. They afterwards enclose themselves in a small cocoon of silk, which is often covered with dust; and in this they undergo their change into the Pupa state. In the Imago, the rudiments of wings are visible, in the form of little scales, attached to the second and third segments of the body; there is, however, no proper distinction of thorax and abdomen.—The Common Flea

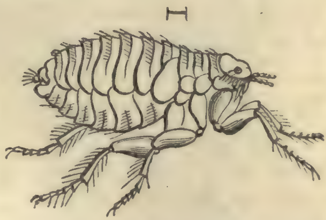


Fig. 431.—The Flea. (*Pulex irritans.*)

is known to every one. There is a very curious species, of more minute size, in the West Indies; which is commonly known under the name of *Chigoe* or *Jigger*. This burrows beneath the skin of the foot, and soon acquires the size of a pea, by the enormous growth of the abdomen when distended with eggs. If these eggs remain to be hatched beneath the skin, great irritation, and even very troublesome sores, are sure to result; and it is consequently necessary to extract the insect entire, with great care, as soon as the indication of its presence is given by a slight itching or tingling.

Order X.—ANOPLURA.

736. The Insects of this Order,—the *Louse* and its allies,—are regarded with the greatest disgust by the common consent of civilized Man; because their presence on the body is usually an indication of a gross want of cleanliness of habit. Most of the lower animals, however, are infested with one or more species; from the attacks of which they are not able to defend themselves; and Man is subject to a peculiar disease, which seems much to favour their production. They undergo no metamorphosis; and their generations succeed each other very rapidly. They are destitute of the true compound eyes; but have one or two minute ocelli on each side of the head. The legs are short, and terminated by a strong nail, or by two opposing hooks; whereby these animals can easily fasten themselves to the hairs of quadrupeds, or the feathers of birds; of which animals they suck the blood, and upon the bodies of which they pass their lives; attaching their eggs, too, upon these cutaneous appendages.

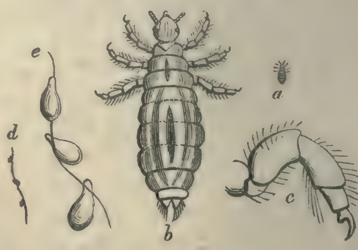


Fig. 432.—*a*, The Common Louse; *b*, magnified; *c*, one of the legs magnified; *d*, eggs; *e*, ditto magnified.

The number of species is very considerable ; for it would appear that almost every quadruped and bird has a kind almost peculiar to itself,—the same Louse not being found upon different animals, except upon such as have analogous characters and habits; whilst one animal frequently supports two or more species of these parasites.

ORDER XI.—THYSANOURA.

737. IN the Insects of this Order,—which resembles the preceding in neither having wings, nor undergoing metamorphosis,—there is a remarkable diversity of structure, especially in regard to the mouth. Some of them possess as complex a buccal apparatus as the Mandibulate Insects ; whilst in others there is scarcely a perceptible opening. The same is the case with regard to the eyes; these organs being fully developed in some, and almost rudimentary in others. — The Order contains two families. In the first, the LEPISMIDÆ, the abdomen is furnished on each side with a row of moveable appendages, like false legs ; and is terminated by long pointed bristles, of which three are usually most remarkable.—The *Machilis* has long antennæ, consisting of a great number of joints ; its palpi also are very large; and its eyes are composed of numerous facets, and occupy nearly the whole head. It frequents stony places, and leaps well with the aid of the appendages to the tail. The *Lepisma*,—of which one species is known under the name of the *Sugar Louse*, from its aspect and habits,—has the eyes very small, composed of few facets, and wide apart ; its body is flat, and is terminated by three threads of equal length, not fitted to assist in leaping.

FIG. 433.—MACHILIS.

—In the PODURIDÆ, the appendages to the sides of the abdomen are wanting; but the extremity of it is prolonged into a forked tail, by which these insects can execute very surprising leaps.

FIG. 434.—PODURA.

This, when not in action, is bent forwards beneath the abdomen; and it is by the sudden extension of it, that the leap is produced. From this conformation, the *Poduras* are commonly known under the name of *Spring-tails.* The scales with which their bodies are covered, are objects of great interest to the Microscopist; for they have a most elaborate and minute structure, which can only be made out by instruments of the best quality; hence they are very valuable *test objects.*

CHAPTER IX.

OF THE CLASS OF ARACHNIDA.

738. This class is composed of Articulated animals, which have a great analogy with Insects, and which are equally fitted to live in the air; but which are distinguished from them at the first glance, by the general form of the body, and by the number of limbs; and which differ also from those animals, in several important particulars of their internal structure. All the Arachnida have the head united with the thorax, and are destitute of antennæ; they have *four* pairs of legs and no wings; most of them breathe by means of air-sacs, instead of by prolonged tracheæ; and nearly all of them have a complete circulating apparatus.

FIG. 435.—MYGALE.

739. The tegumentary skeleton of Arachnida is generally less firm than that of Insects; and their body is composed of two principal parts, nearly always distinct:—one called the *cephalothorax*, because it is formed by the head and the thorax united into a single mass;—the other termed the *abdomen*, and composed sometimes of a series of distinct rings (such as we see in the Scorpions—Fig. 447), and sometimes of a soft globular mass, without any evident divisions (as is the case among the ordinary Spiders—Fig. 442).

740. The organs of locomotion are all fixed to the cephalothorax, and consist of eight legs, very similar to those of Insects, and nearly always terminated by two hooks. In general their

length is considerable and they easily break; but, as amongst the Crustacea, the stump, after being healed, produces a new limb; which grows by degrees, and becomes similar to the one of which the animal had been deprived. The Arachnida never present any vestige of wings: and their abdomen is always entirely destitute of locomotive appendages.

741. Upon the anterior portion of the cephalo-thorax, we find the mouth and eyes. These last organs are always simple, and of considerable number. We may generally count eight, and in each of them may be distinguished a transparent cornea, behind which is found a crystalline lens, and a vitreous humour; then a retina formed by the termination of an optic nerve, and an envelope of colouring matter.—Nothing is known regarding the instruments by which the sense of hearing operates in the Arachnida; but there are numerous proofs of the existence of such a faculty amongst these animals; and it would even appear that certain of them are sensible to the charms of Music.—The sense of touch is exercised principally at the extremities of the legs, and by the appendages with which the mouth is furnished.

Fig. 436.

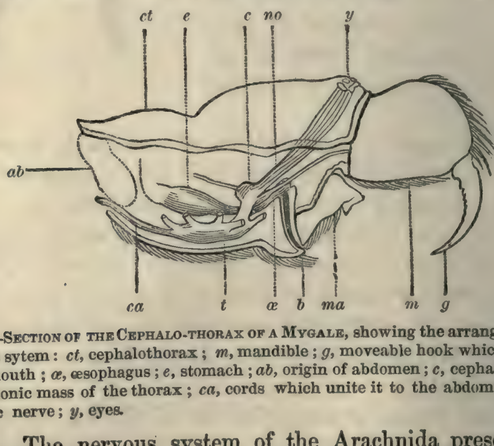


Fig. 437.—Section of the Cephalo-thorax of a Mygale, showing the arrangement of the nervous sytem: *ct*, cephalothorax; *m*, mandible; *g*, moveable hook which terminates it; *b*, mouth; *æ*, œsophagus; *e*, stomach; *ab*, origin of abdomen; *c*, cephalic ganglion; *t*, ganglionic mass of the thorax; *ca*, cords which unite it to the abdominal ganglia; *no*, optic nerve; *y*, eyes.

742. The nervous system of the Arachnida presents very great differences; sometimes (amongst the Scorpions for ex-

ample) it is composed of a series of eight ganglionic masses, united together by double cords of communication, and forming a chain extended from one end of the body to the other, in nearly a uniform manner; in other instances (as amongst the Spiders, &c.) we find all the ganglia of the thorax united into a single mass (*t*, Figs. 437 and 439), whence two cords proceed backwards, which go to a single abdominal ganglion. In other respects, the general arrangement of these parts is always the same. The anterior ganglia, situated before or above the œsophagus, and most commonly considered as representing the brain of these animals, give origin to the optic nerve in front, and are continuous behind with the collar of nerves surrounding the œsophagus; the other ganglia are situated below the alimentary tube, and send nerves to the limbs, to the appendages of the abdomen, &c.

743. The Arachnida are carnivorous, but in general confine themselves to sucking the juices contained in the bodies of their victims; and in order to enable them more easily to effect the capture of animals of whose strength they would be afraid, Nature has endowed many of them with a poisonous apparatus. The greater part are supported on Insects, which they seize whilst alive; some of them, however, live as parasites. Among the first, the mouth is supplied with a pair of mandibles, furnished with moveable hooks, or formed like a pair of pincers,—with a pair of thin or lamellated maxillæ, each bearing a large feeler more or less resembling a leg,—and with a lower lip. Amongst the parasitical Arachnida, the mouth has the form of a small trunk, from which there issues a kind of lancet formed by the maxillæ.

FIG. 438.—BUCCAL APPARATUS OF A SPIDER: *s*, sternum; *l*, labrum; *ma*, maxillæ; *p*, maxillary palpi; *m*, mandibles; *g*, hook terminating the mandibles.

744. The moveable hook of the mandibles has a small opening near its extremity, which is the orifice of the excretory canal of the poison-gland already mentioned; and the liquid, which it pours into the bottom of the wounds made with the mandibles, almost immediately causes the destruction of the animal attacked; but it is too weak to injure Man.

745. Certain of the Arachnida are provided with another poison apparatus, destined for the same use, and serving equally as a weapon of defence: such is the hook by which the abdomen of Scorpions is terminated (Fig. 449). This sting has beneath its point several openings, which communicate with a poison-gland; and the sting of these Arachnida often proves mortal, even to animals as large as Dogs. The large Scorpions of warm countries are fatal even to Man, but the sting of the species which inhabit Europe never appears to be mortal; there usually results from it a local inflammation more or less violent, accompanied by fever and depression, and sometimes by vomiting, pains in the whole body, and trembling. To overcome these attacks, physicians advise the use of ammonia (or spirit of hartshorn), administered internally as well as externally; and the application of emollient substances to the wound.

746. The intestinal canal is generally very simple; but has sometimes cæcal appendages, which penetrate even into the interior of the limbs. In general, tubes analogous to the biliary

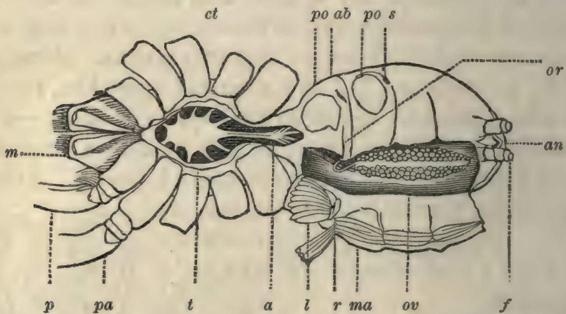


Fig. 439.—Anatomy of Mygale: *ct*, cephalothorax opened below, and giving attachment to the limbs, whose first joints are exhibited; *pa*, legs of the 1st pair; *p*, palpi; *m*, mandibles; *ab*, abdomen; *t*, thoracic nervous mass; *a*, abdominal ganglia; *po*, respiratory sacs; *s*, stigmata; *l*, leaf-like folds in the interior of one of these laid open; *ov*, ovaria; *or*, orifice of oviducts; *ma*, muscles of the abdomen; *an*, anus; *f*, spinnerets.

vessels of insects open into the intestine near the anus; but amongst some of the Arachnida, such as the Scorpions, there exists a liver composed of four glandular clusters. It is also in

the neighbourhood of the anal opening, that we find the secreting glands of the silky matter; and also the spinnerets, by whose aid several of the Arachnida weave for themselves webs, which are often very extensive and of extreme delicacy.

747. The respiration of the Arachnida is aërial, like that of Insects, and is sometimes effected by means of tracheæ; but among the greater part of these animals, and especially amongst the Spiders and Scorpions, it is concentrated in certain vesicles lodged in the abdomen, and called pulmonary sacs. These last organs have in their interior a multitude of membranous plates, arranged like the leaves of a book: and they thus bear a stronger resemblance to internal gills, than to true lungs. Each sac receives the air by an opening situated on the lower side of the abdomen; and there are sometimes two, sometimes four, or even eight of these stigmata. Certain Arachnida possess at the same time both pulmonary sacs and tracheæ; the *Segestriæ* are thus formed. Others, such as the *Pseudo-Scorpions* and *Mites*, are provided with tracheæ only. These tubes have the same structure as in Insects; and the air penetrates to them by two very small stigmata, situated on the lower side of the abdomen.

748. The blood is white among all the animals of this class. The pulmonary Arachnida are furnished with a complete circulating apparatus. The heart, situated on the back, has the form of a long vessel, and gives origin to different arteries; the blood after having traversed the body is returned to the pulmonary sacs, and arrives at the heart after following a course similar to that which it traverses in the Crustacea (ANIM. PHYSIOL. § 292). Amongst the Arachnida whose respiration is effected only by the aid of tracheæ, the apparatus for circulation is but little developed; there appears to be only a simple dorsal vessel, without arteries or veins.

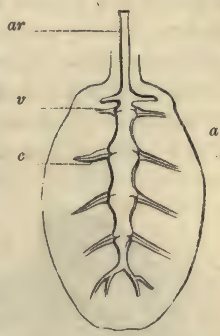


FIG. 440.—HEART OF A SPIDER: *a*, border of the abdomen; *c*, heart; *ar*, large artery, proceeding from its anterior extremity; *v*, pulmonary vessels.

749. The Arachnida lay eggs like Insects; and the male differs in general from the female in the form of its maxillary

palpi, whose use appears to be very important; a great number of these animals envelop their eggs in a cocoon of silk; and sometimes the mother remains with her young family to protect it, and even carries the young ones on her back when they are too weak to walk. All these animals undergo several changes before they arrive at adult age; and certain of them experience a species of metamorphosis, for there are some, whose limbs consist at first of only three pair, and which acquire a fourth at a period more or less advanced.

750. The Arachnida are endowed with varied instincts, which are sometimes not less remarkable than those of Insects; and we are perhaps even to attribute to them higher faculties; for some animals of this class are capable of undergoing a kind of education, and give evidences of a certain degree of Intelligence. Several of them use particular stratagems to carry off their prey; and others display singular industry in the construction of their habitations. We have elsewhere had occasion to speak of the remarkable nest of the *Mygale* (ANIM. PHYSIOL. § 700); and the webs which our garden Spiders spread with such admirable regularity, are equally curious. The silk with which these animals thus construct retreats for themselves, spread snares for their prey, and form cocoons for their eggs, is secreted by an apparatus situated in the posterior part of the abdomen. This apparatus consists of several bundles of vessels, twisted together, and terminating in minute apertures, which are pierced at the summit of four or six conical or cylindrical projections, called *spinnerets*, and situated at the end of the tail. The gluey matter thrown out through these pores, acquires consistency by its contact with the air, and consists of threads of an extreme fineness, and a length not less remarkable; by the help of its feet, the animal collects a number of these threads into a single cord; and each time that, in balancing itself, the spinnerets touch the body upon which it rests, it there

FIG. 441.—NEST OF MYGALE.

fastens the end of one of these threads, of which the opposite extremity is still inclosed in the secreting apparatus, and of which it can consequently increase the length at pleasure. The colour and thickness of these threads vary greatly; a Mexican Spider forms a web composed of red, yellow, and black threads interwoven with astonishing skill; and it has been calculated that ten thousand threads from the pores of a single spinneret of some of our common Spiders do not equal in thickness one of our own hairs; whilst among other species inhabiting warmer climates, they form such strong webs, that they are sufficient to stop small birds, and even Man has to use some effort to break them. The manner in which Spiders employ their skill in working, is subject to no less variation; some of them are satisfied with spreading their threads irregularly; others weave a web, whose meshes are of extreme regularity. Sometimes we see them motionless in the middle of their web, watching for their prey; at other times they conceal themselves in a retreat, which they construct very near, and which has in some instances the form of a silky tube, in others that of a small cup.

751. The Arachnida are divided into two orders, according to the structure of the organs of respiration and circulation.

I. The *Pulmonary* Arachnida; which are principally characterised by the existence of pulmonary cavities, and by a vascular apparatus; but we may also recognise them by other peculiarities of structure; thus the number of their eyes is six, eight, or even still greater, and we also find two, four, or eight stigmata on the under part of the abdomen. The general form of these animals varies; some, as the Spiders, have a globular body, with spinnerets at its extremity, and the palpi small;—whilst in other instances, as the Scorpions, the body is lengthened, and composed of several rings, the palpi large, extended like arms, and armed with pincers; and the abdomen is not terminated by spinnerets, but usually by the poisonous apparatus.

II. The *Tracheary* Arachnida; which have no pulmonary sacs, but breathe by tracheæ like Insects, and appear to have no complete vascular apparatus for the circulation of the blood. Some of them have no eyes; and amongst those which possess these organs,

we never find more than two or four. Some of these animals, known under the name of *False-Scorpions*, very much resemble Spiders, and are remarkable for the length of their limbs; others have the mouth formed for sucking, and constitute the family of *Acaridæ*, or Mites.

ORDER I.—PULMONARIA.

752. By the characters just now stated, this order may be divided into two sections;—the ARANEIDA, or *Spiders*, having small foot-like palpi, not terminating in pincers; and the PEDIPALPI, or *Scorpions* and their allies, having very large palpi, which terminate in pincers or large hooks.

753. Section I. ARANEIDA. The Arachnida of this group all agree, more or less closely, with the common Spider, in their form and structure. Their cephalothorax appears as if composed of but a single segment, and is covered with a sort of horny buckler, usually of oval form; the abdomen is appended to it by a very short footstalk, and usually consists of a soft and tumid mass. The eyes are nearly always eight in number; although there are sometimes but six. The mandibles terminate in a very sharp moveable hook, which is pierced near its extremity by a small aperture, serving as a passage for the poison secreted by a gland lodged in the preceding joint. The legs are inserted almost in a circular manner around the cephalothorax (Fig. 439); they are all of nearly the same form; and each of them is composed of seven joints, the last being armed with two hooks, which are commonly toothed like a comb. The pulmonary sacs in this order are only two in number, or may even be reduced to a single one; they are placed near the base of the abdomen, and their position is indicated externally by a brownish or whitish spot. All the members of this section are provided with spinnerets; but it is only in a comparatively small number, that we find the power of constructing silken webs of any great extent. The ARANEIDA are divided by M. Walcknäer, who has made this group his especial study, into families, according to the

arrangement of the mandibles and eyes, which corresponds very remarkably with their respective modes of life. These families, and their principal subdivisions, are as follows :—

I. VENANTES, incessantly running or leaping about the vicinity of their abode, to chase and catch their prey.	LATEBRICOLÆ, hiding in holes and fissures. TUBICOLÆ, inclosing themselves in silken tubes. CELLULICOLÆ, sheltering themselves in small cells. CURSORES, running swiftly to catch their prey. SALTATORES, leaping and springing with agility to seize their prey.
II. VAGANTES, wandering abroad, and incessantly looking out for prey. No fixed residence except at the period of oviposition.	LATERIGRADÆ, walking and running sideways or backwards ; occasionally throwing out threads to entrap their prey.
III. ERRANTES, prowling about the neighbourhood of their nests, or near the threads which they throw out to catch their prey.	NITIDELÆ, going abroad, but making a web for their nests, whence issue threads to entrap their prey. FILITELÆ, going abroad, but spreading long threads of silk about the places where they prowl, in order to entrap their prey.
IV. SEDENTES, spinning large webs to entrap their prey, lying in wait in the middle or at the side.	TAPITELÆ, spinning great webs of a close texture, and dwelling therein to catch their prey. ORBITELÆ, spreading abroad webs of a regular and open texture, either circular or spiral, and remaining in the middle or on one side to catch their prey. RETITELÆ, spinning webs of an open meshwork, and of an irregular form, and remaining in the middle or on one side to seize their prey.
V. NATANTES, swimming in water, and there spreading their filaments to entrap their prey.	AQUITELÆ, spreading filaments in the water to entrap their prey.

754. The first family, that of the VENANTES, or *Hunting-Spiders*, may be naturally divided into two groups; the first being more sedentary, and the second more active. At the head of the first group stands the tribe of LATEBRICOLÆ, which consists of the genus *Mygale* (Fig. 435) and its allies ; these are the largest of the whole family, some of them occupying, in a state of repose, a circular space of six or seven inches in diameter. They form their nests in the slits of trees, beneath the bark, in the cavities of stones and rocks, or on the surface of the leaves of various trees. Some of them burrow deeply into the ground, choosing dry shelving situations exposed to the sun, and con-

structing subterranean cylindrical galleries, often two feet deep, and so tortuous that it is difficult to follow them. These they line with a silken tube, forming at its entrance a moveable lid, composed of silk and earth, attached to the silken lining by a sort of hinge; and this is adapted, by its size, situation, and weight, to close the opening so precisely, as scarcely to allow its entrance to be distinguished from the neighbouring soil,—shutting of itself when the Spider enters its retreat or passes out of it. When an attempt is made to open it from without, the Mygale holds it down firmly with its hooked feet. The Mygale spins a sort of cocoon around its eggs, enclosing a hundred or more; they are hatched within it, and the young undergo their first changes before quitting it. The various species of this group are inhabitants of tropical and the warmer temperate climates; it is only in the former, that we find those of largest size.—The TUBICOLÆ and CELLULICOLÆ are not sufficiently distinct from the preceding, to require particular notice. They are mostly of smaller size, and inhabit temperate climates, where they may be considered as representing the Mining Spiders.

755. The tribes of CURSORES, or *Runners*, and SALTATORES, or *Leapers*, forming the second division of the Hunting-Spiders, are distinguished by the activity with which they pursue their prey. The former, which are sometimes called Wolf-Spiders, have the legs adapted for running, and live mostly upon the ground. Those of the genus *Lycosus* dwell in holes which they have formed, lining their inside with silk, and increasing their size as they grow. Some of them take up their abode in holes of walls, where they make silken tubes; the outside of which they cover with earth or sand, and in which they moult or hybernate, having first closed the entrance. The females also lay their eggs in these tubes; inclosing them in a silken cocoon, or egg-case, which they carry about with them when they go out to hunt. The young ones fasten themselves, as soon as they are hatched, upon the body of their parent; and there remain attached, until they are sufficiently strong to seek their own food. These Spiders are very voracious, and defend their habitations and young with great courage. A species of this genus,

the *Tarentula*,—so named from the city of Tarentum, in Italy, in the neighbourhood of which it is common,—is very celebrated on account of its reputed venomous powers. Like all the Spiders, it has a poison-gland in its mandibles; but the idea that its wounds are followed by death, or by a complaint termed Tarantism, which can only be cured by the aid of music and dancing, has originated in the imagination only.—Some species of the genus *Dolomedes* live upon the tops of trees, upon the leaves of which they make a funnel-shaped silken nest; whilst others inhabit plants in the neighbourhood of water, on which they find their prey,—running upon its surface with surprising quickness, and even entering it without being wetted.—The Spiders of the tribe of SALTATORES, or *Leapers*, have, as might be anticipated from their name, the legs fitted rather for leaping than for running. One of these is very common in summer upon walls and windows exposed to the sun; and its habits may be watched with much interest. It moves in short leaps, and stops suddenly at intervals, raising itself upon its legs, as if to survey the neighbourhood. When it discovers a fly, or especially a gnat, it approaches it cautiously until within leaping distance; when it darts upon it,—not fearing to take even a perpendicular leap, because it always at the same time suspends itself by a thread, which it winds off as it advances. This thread also serves to suspend it in the air, and enables it to mount up again to the spot from which it leaped, or to sustain it whilst the wind carries it from place to place. Many species of this group construct, amongst leaves, under stones, &c., silken nests, in the form of oval sacs, open at each end; into which they retire in order to take rest, to moult, and to take refuge against the inclemency of the weather. If menaced with danger, they quit these retreats, and run off very rapidly. Some species construct, with the same material, a kind of tent, which serves as the birthplace of their posterity, and in which the young reside for some time with their parent.

756. The family VAGANTES, or *Wandering Spiders*, consists of the single tribe LATERIGRADA; the name of which (meaning Side-Walkers) expresses the curious power which they possess,

of moving sideways. They conduct us towards the web-spinning Spiders, in using their silken threads, not only for the construction of habitations for themselves or of envelopes for their eggs, but also for the purpose of entrapping prey. The threads, however, are not arranged with any regularity, but are laid singly. These Spiders generally remain at rest, with the legs spread out, upon the leaves or stems of plants; running, however, with great rapidity, in pursuit of their prey, when it comes within their reach. Others, however, live in rocky places; and have the feet so formed, that they can adhere even to very smooth surfaces, in any position of their own bodies. They usually construct very elaborate cocoons for the protection of their eggs. Those which live among plants affix the cocoons to the leaves, and draw together their edges so as to conceal them. Those, on the other hand, which live upon rocks, usually conceal the cocoon within their own dwelling-place; which is an oval conical tent, something like a Limpet in form, attached at its base to the rock, but having an aperture at each end, furnished with a kind of valve through which the animals go in and out. The outer covering of this tent is composed of a sort of yellowish taffety, thin (like the skin of an onion), but resisting; whilst the inner covering is soft and pliant.

757. The Spiders of the family ERRANTES, or *Prowlers*, are divided into two groups, chiefly according to the situation in which they throw out the silken lines for the entanglement of their prey. The first tribe, that of NITIDELÆ, contains species that only prolong these threads from their nests, which are formed under stones in holes of walls, the hollows of leaves, and similar situations. These species much resemble those of the last tribe in their habits; but differ in many points of structure. —In the second tribe, the FILITELÆ, the threads are spread about the places, in which these Spiders prowl in pursuit of their prey. Among these, the *Clotho*, which inhabits Egypt and the South of Europe, is remarkable for the curious habitation which it constructs for its young. This is a kind of limpet-shaped cocoon, about an inch in diameter, of which the circumference has seven or eight festoons; the points of these festoons being

alone fixed to the stone by means of threads, whilst the edges are left free. This singular tent is at first composed of only two folds, between which the Spider takes its station. But subsequently it adds additional folds; and when the period of reproduction arrives, it weaves another apartment, of a softer texture, expressly for the reception of the sacs of eggs, and of the young when hatched. The inside of its habitation is singularly clean. The bags in which the eggs are placed, are about one-third of an inch in diameter; and there are from four to six of them in each habitation. The eggs are not deposited until the end of December or January; and they are enveloped in fine down, to guard them from the cold. The parent creeps in and out beneath the edges of the festoons; and supplies her young with food, for some time after they are hatched. When they are able to dispense with maternal cares, they quit their common habitation, and form separate abodes; and the parent dies within her tent.

758. The last family, SEDENTES, or *Sedentary Spiders*, contains all those species with which we are most familiar, from the annoyance they cause us by the construction of their webs in our houses and gardens.—Of the first tribe, TAPITELÆ,—which construct a sort of tapestried web of close texture, within which they dwell and wait for their prey,—the common *House-spider* is a characteristic example (Fig 442).—The Spiders of the second tribe, ORBITELÆ, have the abdomen larger, softer, and more coloured than the preceding; they make their webs with regular meshes; arranged in concentric circles crossed by straight radii; and they usually remain stationary in the centre, in a reversed position (Fig. 443). Many species, however, construct for themselves a cavity or cell, which is sometimes horizontal and sometimes perpendicular, near the edges of the net. Of this group, the genus *Epeira* is the principal; of which several species abound in our gardens, especially during the autumn. The eggs are deposited by the parent at the commencement of cold weather, in angles of the ceilings of rooms, passages, &c., near gardens; they are enveloped in a loose white web; and are hatched in the spring of the following year. Some species of

Epeira inhabit the neighbourhood of running streams, and feed upon aquatic insects. Another is remarkable as being nocturnal

FIG. 442.—TEGENARIA DOMESTICA, OR HOUSE-SPIDER.

in its habits. The natives of New Holland and the South Sea Islands, when in want of other food, are said to devour a species of Epeira. — The RETITELÆ bear a close resemblance to the preceding, both in the aspect of their bodies, and in the construction of their webs ; but these are not formed on a regular plan, the threads crossing in all directions and leaving irregular meshes. When their prey is entangled in

FIG. 443.—EPEIRA DIADEMA.

their web, they whirl threads around it, so as to secure it effectually. They take great pains in the preservation of their eggs, and do not leave them until they are hatched. In one common species which frequents our dwellings, the female gums her eggs into a rounded body, unprotected by a cocoon; and this she bears about in her jaws. Other species live out of doors, and construct their webs among trees. To this group belongs the *Malmignatte*, an inhabitant of Tuscany and Corsica; which is reputed to be very venomous.

FIG. 444.—MALMIGNATTE.

759. The last family of Araneidæ, the NATANTES, or *Water-Spiders*, closely resembles the preceding in structure; and should scarcely, perhaps, be separated from it. They live entirely upon or beneath the water; and are enabled, by the hairiness of their bodies, especially on their under surface, to entangle and carry down with them a supply of air for their respiration. One very interesting species, the *Argyroneta aquatica*, or Diving Spider, not only employs its silken threads to entangle its prey, but forms with it an oval bag, of such close texture that it is impervious to air or water; this is attached by threads to aquatic plants, at a considerable depth below the surface; and its under side is open, like that of a Diving Bell; so that the Spider can freely pass in and out. Here it retreats to devour its prey; and here, too, it constructs its egg-case, and even passes the winter. The mode in which it fills this with air, when about to take up its residence in it, is very curious. The hairs upon its body entangle so large a quantity of air, as to render it quite buoyant; in order to descend to its bell, therefore, it is obliged to creep along the stems of aquatic plants; and

445.—DIVING SPIDER.

when it has arrived there, it gets beneath its lower edge, and allows the bubbles of air which it had entangled to ascend into it. Then returning to the surface of the water, it brings down a fresh supply of air; and in this manner it gradually fills the bell, which then presents a beautiful silvery or glistening appearance, when seen beneath the surface of the water. This process is strikingly analogous to that, which was first employed to renew the air in Diving Bells; barrels of air being sent down by means of weights, and their air being allowed to pass into the bell, by means of a flexible pipe, when they had been sunk to a lower level.

760. Section II. PEDIPALPI. This section is distinguished by the large size of the palpi, which resemble extended arms, and which are furnished at their extremities, either with moveable hooked claws, or with a pair of pincers, composed of two fingers, one fixed and the other moveable, like those of Crabs and Lobsters. The abdomen is composed of very distinct segments; and is destitute of spinnerets at the tip. The entire body is encased in a hard skin. The cephalothorax is composed of a single piece, and is furnished with six or eight ocelli or eyelets. The number of pulmonary sacs is *four* in one of the two families of which the section is composed, and *eight* in the other. In the first of these families, THELYPHONIDÆ, the general form is that of the Spiders; so that the species included in it are commonly ranked as such. They are, however, at once distinguished by the large size of the palpi, and by the absence of spinnerets. They differ from the Scorpions, on the other hand, in the form of the abdomen; and in the absence of a sting at its extremity. The tarsi of the two fore-legs differ from the others in a remarkable degree; being composed of numerous joints, so slender and prolonged as to resemble threads, and being destitute of the usual hook at its extremity. These Arachnida inhabit only the hottest parts of Asia and America; very little is known of their habits.

FIG. 446.—PHRYNUS RENIFORMIS, reduced.

761. With the characters of the second family, SCORPIONIDÆ, or the *Scorpion* tribe, we are much more familiar. It is especially distinguished from the preceding by its eight breathing-pores; but also by its long-jointed abdomen (the hinder part forming what is commonly called the tail), terminated by a venomous claw or sting. The abdomen is composed of twelve segments; six of which are broad, forming the posterior part of the body, whilst the other six form the tail. Between the thorax and abdomen there is no distinct division. In these particulars, — the evident division of the body into segments, the want of separation between the thorax and abdomen, the multiplication of the respiratory sacs,—as well as in others, the Scorpionidæ show an evident approach towards the Myriapoda. The Arachnida of this tribe inhabit the warm countries of both hemispheres, living on the ground, hiding themselves under stones or other bodies (generally in dark and cool places), and sometimes taking up their abode in the interior of houses. They run quickly, and curve the tail over the back. They can turn it in all directions, and employ it as a weapon of offence or of defence. Their usual food consists of Wood-lice and various Ground-Insects, such as Carabi, Weevils, Orthoptera, &c.; these they seize with their pincer-like palpi, and then prick them with their stings, so as to render them powerless before proceeding to devour them. They are also particularly fond of the eggs of Spiders and Insects. It is only in the larger species of Scorpion, which are five or six inches long, and inhabitants of tropical countries, that the poison is sufficiently powerful to do any serious mischief to Man; and although the effects of the sting

FIG. 447.—SCORPION.

of these are severe, they are seldom, if ever, fatal, except in persons previously unhealthy. It is not generally known, that a small species of Scorpion exists in our own country, as well as on the Continent of Europe; and this has afforded to European Naturalists an opportunity of watching its habits. The female resembles that of the Spiders in her attention to her young; these she carries on her back for several days, at first not quitting her abode; and she afterwards takes care of them for the space of a month, by which time they are enabled to shift for themselves.

ORDER II.—TRACHEARIA.

762. THE Arachnida of this order present a much stronger resemblance to the class of Insects, than do any of the preceding; for they are characterised not merely by the nature of their respiratory organs—which consist of ramified tracheæ, instead of pulmonary sacs—but also by the imperfect development of the circulating apparatus, as well as by a certain degree of metamorphosis, which has been observed in several of them. They may be divided into three families, according to the form of the thorax and abdomen,—these characters being preferred, on account of their being more easily recognised, in the minute animals of which the group consists, than those founded on the structure of the mouth and the mode in which the food is obtained. These families are ;—I. The PSEUDO-SCORPIONIDÆ, or *False-Scorpions*, are so named from the strong resemblance which some of them bear to the preceding group; these have the abdomen very distinct from the thorax, and marked with rings; and are furnished with large palpi, which are either formed like feet (Fig. 448), or furnished with pincers (Fig. 449) :—II. The PHALANGIDÆ, or *Harvest-men*, which may be regarded as representing the Spiders in the Tracheary Order; they have the thorax and abdomen united into one mass, but the latter does not exhibit any division into rings; the palpi are thread-like ;—and III. The ACARIDÆ, or *Mites*, which have the abdomen united to the thorax, but altogether unmarked by rings (Fig. 452).

763. The general form and aspect of the PSEUDO-SCORPIONIDÆ will be best understood from the accompanying figures, which represent two of the principal species. The *Galeodes* is found in the warmer temperate and the tropical regions, principally of the Old World. They run with great quickness, erect their heads when surprised, show signs of resistance, and are reputed to be venomous. The *Chelifer* strongly resembles a small Scorpion deprived of its tail; and one species, which inhabits herbaria, old books, &c.,—feeding upon the minute insects which frequent such situations, is commonly known under the name of Book-Scorpion. It runs quickly, and often sideways, like the Crabs or the Laterigrade Spiders. The eggs are united into a mass, which is said to be carried about under the abdomen.

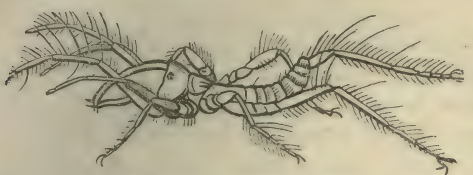


FIG. 448.—GALEODES INTREPIDA.

FIG. 449.—CHELIFER FASCIATUS.

764. Here has been placed, by many Naturalists, a very curious group, the PYCNOGONIDÆ; which departs very widely from the other Arachnida, both in the structure of the body, as well as in the residence, which is exclusively marine. It appears to be destitute of any special Respiratory apparatus; and cannot, therefore, be referred with certainty either to this class or to the Crustacea, by characters derived from the mode in which this function is performed. On the whole, however, its analogies seem to be rather with the latter class; with which, therefore, it will be described (§ 815). It may be regarded as connecting the Arachnida and Crustacea.

765. The PHALANGIDÆ, or Harvest-men, have two thread-like palpi, terminated by a small hook; the legs are long and slender, and when detached from the body, they show signs of

irritability for a few moments. The majority of them live upon the ground, upon plants, or at the roots of trees, and are very

Fig. 450.—Phalangium Cornutum.

Fig. 451.—Gonyleptes Acanthurus.

active in their movements; others hide themselves between stones, or in moss, and are less agile.

766. The Acaridæ, or *Mites*, have the mouth formed rather for suction than for mastication; its various pieces not being separate, as in the other Arachnida, but more or less enveloped in a sort of sheath formed by a prolongation of the lower lip; the maxillary palpi, however, are generally free, and their extremities are commonly armed by a small pair of pincers. Some of these animals have four or two eyes; others have only a single one; and there are several which do not possess any. They are nearly all of very small size, and multiply with great rapidity. Many of them come forth from the egg with only six legs, and may be considered to bear, in this state, a strong resemblance to parasitic insects; they do not acquire their additional pair until after the first moult, which thus becomes a sort of metamorphosis. The Acaridæ are very widely,—in fact universally,—distributed. Some of them are of wandering habits; and amongst these, some are found under stones, leaves, the bark of trees, in the ground, the water, or upon various articles of food, such as meat and old dry cheese, and upon putrid animal matters. Others subsist as parasites upon the skin, and in the flesh of different animals; often greatly weakening them by their excessive multiplication, and producing most violent itching. Other kinds of Mites are parasitic upon Insects; and

many Beetles which feed upon decaying substances, are entirely covered by them. The *Acari*, or *True Mites*, have the legs adapted for walking; and some of them are of active habits. The common *Cheese-Mite* is familiar to every one; and there are many other species which nearly resemble it in structure and habits, but which feed upon different substances. To this group belongs a small species, which appears to be the occasion of one of the most disgusting diseases of the skin,—the itch. It is scarcely visible to the naked eye; but when examined under the microscope, it is seen to have an oval body; a mouth of conical form, armed with several bristles; and eight feet, of which the four anterior are terminated by small suckers, that enable it to adhere firmly to any solid bodies, whilst the four posterior are terminated only by bristles. Some of this Acari have the power of spinning webs, and are commonly ranked with the Spiders; one of these is well-known as the Red Spider in hot-houses, where it greatly injures the plants by covering the leaves with its webs.—The *Riciniæ*, commonly known as *Ticks*, are usually destitute of eyes, but have the mouth provided with lancets, that enable them to penetrate more readily the skins of animals whose blood they suck. They are usually of a flattened, round, or oval form; but they often acquire a very large size by suction, and become distended like a blown bladder. They are found in thick woods, abounding in brushwood, briars, &c., and attaching themselves to plants with the two fore legs. They fasten upon dogs, cows, horses, and other quadrupeds, and even upon the tortoise; and they bury their suckers (which are often furnished with minute recurved hooks,

FIG. 452.—ACARUS DOMESTICUS, OR CHEESE-MITE, magnified.

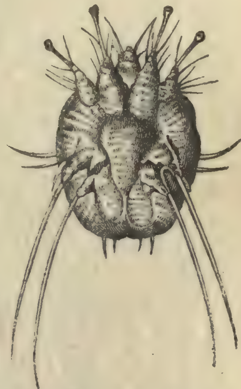


FIG. 453.—SARCOPTES SCABIEI, OR ACARUS OF THE ITCH.

as in the *Ixodes*, Fig. 454,) so firmly in their skin, that they can hardly be detached by force,—the portion of skin to which

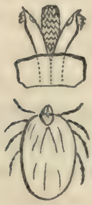


FIG. 454. — IXODES PLUMBEUS, AND ITS BEAK, magnified.

FIG. 455.—*a*, HYDRACHNA GLOBULUS; *b*, magnified; *c*, young larva; *d*, pupa.

they are attached coming away with them. It is probably the young of a species of this group, which is commonly known as the *Harvest-Bug;* this is very common in the autumn, upon grass or other herbage; and insinuates itself into the skin at the roots of the hair, producing a very painful irritation. In this state it possesses only six legs.—Lastly, there is a tribe of Acaridæ, the *Hydrachnæ*, in which the legs are covered with hairs, in such a manner as to adapt them for swimming; these are all, during a part of their lives at least, parasitic upon various Water-Insects, such as the Dytiscus, the Nepa, &c. These Water-Mites undergo a more complete metamorphosis than any of the preceding; for the larvæ have a very large head, and six legs; whilst the pupæ have but a single pair of legs, with which they attach themselves to the bodies of insects, and present the appearance of an oval bag with a narrow neck.

CHAPTER X.

CLASS OF CRUSTACEA.

767. CRUSTACEA are Articulated animals, respiring by *branchiæ* or external gills, or by the general surface, and possessing a circulating apparatus, and separate sexes. Crabs and Lobsters are the types of this group; but a great number of animals of a much less complicated structure, and of a different external form, are also classed with these; for as we descend the natural series formed by these animals, we see the same general plan of structure gradually modified and simplified. The lowest Crustacea are even so imperfect, that they can only exist, attached like parasites, on other animals: whence most Naturalists have placed them with the Intestinal Worms.

768. The tegumentary skeleton of Crustacea generally possesses a very considerable degree of firmness. It has nearly always a stony hardness; and indeed contains a very considerable proportion of carbonate of lime. We may look upon this solid envelope as a kind of epidermis; for beneath it we find a membrane like the true skin of higher animals; and at certain times it detaches itself and falls off, in the same manner as the epidermis of Reptiles separates itself from their bodies (§ 471), and as we have also seen the enveloping membrane of the larvæ of Insects renew itself several times. We can easily understand the necessity of this change, in animals whose whole bodies are inclosed in a solid case; which, not being able to grow like the interior parts, would oppose an invincible obstacle to their development, if it could not be thrown off, as soon as it has become too small to lodge them commodiously. Thus the Crustacea change their skin during the whole time of their growth; and it would seem that the greater part of these animals grow during their whole life. The manner in which

they free themselves from their old shell is exceedingly singular. In general they manage to get out of it without occasioning the least change in its form; and when they have quitted it, the whole surface of their body is already clothed in a new casing,—which, however, is still soft, and does not acquire its requisite solidity for some days.

769. The body of Crustacea is composed of a series of rings, more or less distinct. Sometimes most of these segments are simply articulated one with the other, so as to admit of a considerable degree of motion, as in the Sandhopper; sometimes they are nearly all soldered together, and are only distinguished by furrows situated at their line of juncture; lastly, in other cases, their union is still more close, and it is only by analogy that we are led to consider the trunk, resulting from their juncture, as made up of several rings, rather than of one only. Hence result, as we can easily understand, very great differences in the form of these animals; and if we compare with each other a Woodlouse (Fig. 457), a Sandhopper (Fig. 456), and a Crab (Fig. 458), we might be at first led to believe them formed according to types entirely different; but a deeper study of their structure shows, that the composition of their tegumentary skeleton is essentially the same, and that the differences lie almost entirely in this,—that most of the rings being quite distinct and moveable in the Woodlouse, are grown together in the Crab, and that certain analogous parts do not present the same proportions in both animals. Thus in the Woodlouse and Sandhopper we find a distinct head (c) followed by a thorax composed of seven rings similar to each other (t^1 t^2), and each

FIG. 456.—SANDHOPPER.

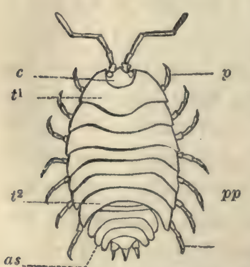


FIG. 457.—ONISCUS, OR WOODLOUSE.

ring provided with a pair of legs (p, pp,) : and at the posterior part of the body we see an abdomen, also composed of seven segments (as), whose size diminishes rapidly, but whose form is nearly the same as in the thorax. In the Crab (Fig. 458), on the contrary, the head is not separated from the thorax; and it forms, with the whole middle part of the body, but a single mass, covered by a large solid buckler called the *carapace*. The abdomen, at first, escapes observation; for it is bent down under the thorax, and is of small size. Yet it is easy to show, that in the Crab, as in the Woodlouse, there are seven very recognisable thoracic rings, and that the carapace is not a new part introduced instead of the former, but merely the dorsal portion of one of the rings of the head, so extremely developed that it has encroached upon all the neighbouring rings.

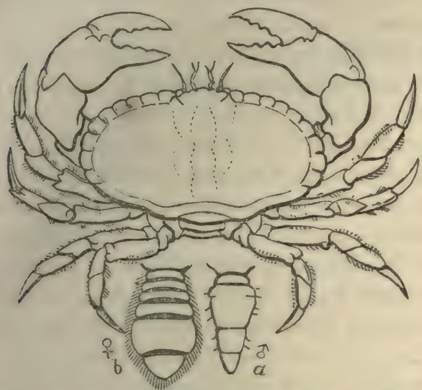


FIG. 458.—CANCER PAGURUS, *Linn.*, with the tail of the male, a; and of the female, b.

770. In other animals of the same class, the general form of the body differs still more widely from those of which we have just spoken. Thus the *Limnadiæ* are inclosed between two oval shields, joined like the valves of an Oyster, and it is only after having raised this moveable cuirass, that we first perceive the annular structure of the body (Fig. 490); the *Cypris* (Fig. 495), which abounds in stagnant waters, presents a similar arrangement: but the rings of which its body is composed, are still more difficult to recognise. Lastly, we may advert to the *Lerneæ*, which at their adult age present the strangest forms; but which, in the earlier part of their existence, possess a regular annular structure (Figs. 501, 502). This comparative study of

the tegumentary skeleton is of great interest as a department of Philosophic Anatomy; one of whose most important branches has reference to those modifications, to which Nature subjects the same organic elements, in order to adapt them to various purposes, and to create different animals from analogous materials; but the limits we have assigned ourselves, do not permit us to dwell longer on this subject.

771. The lateral appendages of the different rings constituting the body, are in general very numerous, and present considerable differences in their conformation and uses;—both when we consider those in the different parts of the same individual, and when we compare them in distinct species. Those of the first pair are generally subservient to the animal functions, and support the eyes or constitute the antennæ; the next surround the mouth, and serve for the prehension or division of the food; those of the middle part of the body constitute the legs for locomotion; and those which are placed behind have various uses, but are generally subservient to respiration or reproduc-

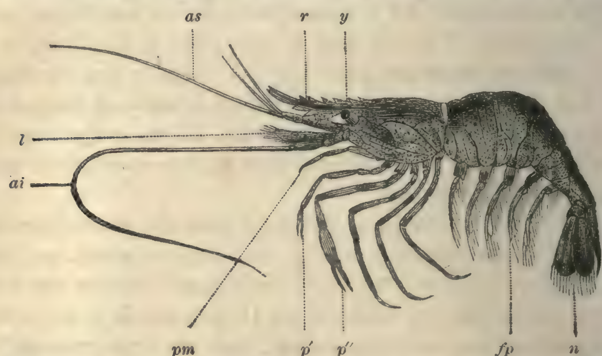


FIG. 459.—PRAWN:—*as*, antennæ of the first pair; *ai*, antennæ of the second pair; *l*, laminar appendage covering its base; *r*, rostrum, or frontal prolongation of the carapace; *y*, eyes; *pm*, external foot-jaw; *p′*, first thoracic member; *p″*, second thoracic member; *fp*, false legs, or swimming members, of the abdomen; *n*, tail-fin.

tion; lastly, this long series ordinarily terminates by one or several pairs of members, which serve as fins.

772. The head, or rather the cephalic portion of the body, carries the eyes, the antennæ, and the appendages of the mouth.

It is sometimes divided into several distinct rings, as in the *Scillæ;* but in general there is no separation, and it is formed of a single piece, which seems to represent seven segments joined together. Sometimes it is moveable, and distinct from the thorax (Fig. 458); sometimes, on the contrary, it is joined to this second part of the body, which in its turn is composed of distinct rings, articulating with each other in some species, but in others united into a single mass.

773. Of the antennæ, there are nearly always two pair; and they are generally thread-like, and very much elongated (Fig. 459, *as* and *ai*). The legs originate by pairs from the different thoracic rings; and they often amount to seven pairs, as for example in the Woodlouse (Fig. 457), and Sand-hopper (Fig. 466); but in other instances, as we see in Crabs (Fig. 458) and Cray-fish (Fig. 471), their number is reduced to five pairs; those appendages, which in the former constituted the four anterior legs, being subjected in the latter to other uses, and transformed into organs of mastication (§ 775). There are also very great differences in their structure: in some Crustacea they are leaf-like, membranous, and fitted for swimming only (Fig. 490); in others they look like little columns jointed together, and adapted for walking only; in others, while yet remaining appropriate to this last kind of locomotion, they are destined to be used also as so many little spades for digging in the earth, and then they are enlarged and laminated at the end (Fig. 460); lastly, in others, they end in pincers, and thus become instruments of prehension, at the same time that they fulfil their ordinary functions in locomotion (Figs. 471 and 505). In swimming Crustacea, such as Cray-fish, Lobsters, Prawns, &c. (Fig. 459), the abdomen generally attains a considerable development, and ends in a large fin, in such a manner as to become the principal agent in

FIG. 460.—HIPPA.

locomotion; but in those which are destined to walk rather than to swim, this part is generally very small and bent under the thorax. In the Crabs, for instance, this portion of the body is reduced to almost nothing, and forms a sort of moveable appendage, which is seen on the inferior surface of the body beneath the legs (Fig. 458).

774. The Nervous System of Crustacea consists of a double series of ganglia, situated on the ventral surface of the body, near the central line. In general their number corresponds to that of the distinct segments composing the body; and the first pair is always placed on the head, in front of the œsophagus, where it forms a sort of brain. The arrangement of the thoracic and abdominal ganglia, however, varies considerably; sometimes they are placed at equal intervals, and form, with their cords of communication, a chain extending from one end of the body to the other; sometimes they approach one another more or less closely; and sometimes they are united, forming a single mass, situated about the middle of the thorax (Fig. 461, *t*). It may be remarked that this concentration of the nervous system becomes more and more complete, as the animal acquires a higher organisation. The Crustacea have in general but very limited faculties; and none among them present much to interest, as to their habits. The eyes are formed nearly in the same manner as in Insects; sometimes they are simple, but in general they are compound; and in all the most perfect Crustacea, these

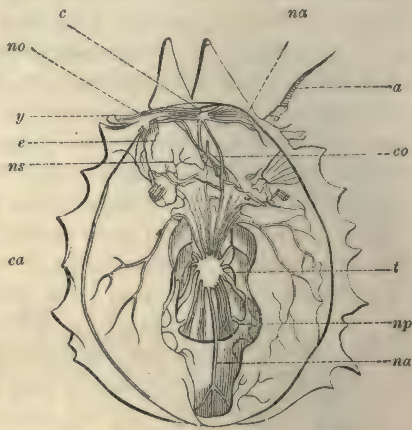


FIG. 461.—NERVOUS SYSTEM OF CRAB (*Maia*): *ca*, upper part of the shell laid open; *a*, antennæ; *y*, eyes; *e*, stomach; *c*, cephalic ganglion; *no*, optic nerves; *co*, œsophageal collar; *ns*, stomato-gastric nerves; *t*, thoracic ganglionic mass; *np*, nerves of the legs; *na*, abdominal nerve.

organs are situated on moveable footstalks (Fig. 462); an

FIG. 462.—PODOPHTHALMA.

arrangement which we do not see in any other division of Articulated animals.—In many Crustacea, there is an apparatus for hearing, situated at the base of the external antennæ, and composed of a small membrane, under which we find a sort of vestibule filled with liquid, and inclosing the termination of a particular nerve. This constitutes the simplest form of an Auditory apparatus. (ANIM. PHYSIOL. § 512). We know nothing positive concerning the senses of Smell and Taste in these animals.

FIG. 463.—Anterior part of the inferior surface of the body of a Crab (*Maia*): *ai*, internal antennæ; *a*, external antennæ; *y* eyes; *o*, organ of hearing; *m*, feet-jaws; *b*, mouth; *p*, base of the anterior limbs; *r*, entrance to the respiratory cavity; *s*, sternum.

775. Most Crustacea subsist on animal substances; but they present great differences in their regimen, some being only nourished upon liquid matters, whilst others feed upon solid aliment; and we observe corresponding differences in the formation of their mouths. In masticating Crustacea there is in front of this opening a short transverse lip, followed by a pair of mandibles, by an inferior lip, by one or two pairs of jaws properly so called, and generally by one or three pairs of auxiliary jaws, or feet-jaws, which serve principally for the prehension of food

(Fig. 472). In suctorial Crustacea, on the contrary, the mouth is prolonged into a sort of beak, or trunk, as we have already seen in Insects of the same habits. In the interior of this tube, we find thin and pointed appendages, which perform the office of little lancets; and on each side we commonly see organs, which are analogous to the auxiliary jaws of masticating Crustacea, but which are so formed as to serve to fix the animal on its prey.

776. The digestive canal extends from the head to the posterior extremity of the abdomen; and is composed of a very short œsophagus, a large stomach (*e*, Fig. 466) generally armed interiorly with powerful teeth, of a small intestine, and of a rectum. In some Crustacea, the bile is secreted by biliary

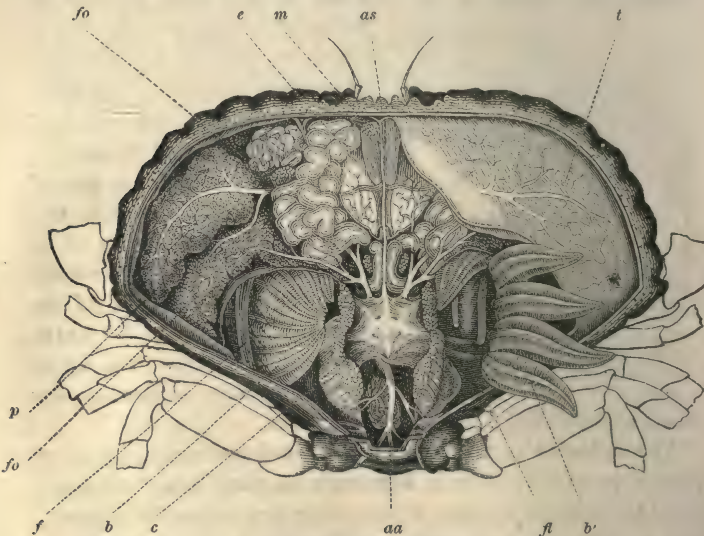


FIG. 464.—ANATOMY OF A CRAB; the greater part of the carapace having been removed; *p*, portion of its lining membrane; *c*, heart; *as*, ophthalmic artery; *aa*, abdominal artery; *b*, branchiæ in their natural position; *b′*, branchiæ turned back to show their vessels; *fl*, lower portion of the shell; *f*, appendage of the foot-jaw; *e*, stomach; *m*, muscles of the stomach; *fo*, liver.

vessels, like those of Insects; but in general there is a very voluminous liver, divided into several lobes, and composed of a

multitude of small tubes terminating in follicles, and grouped round a ramified excretory canal, whose extremity empties itself on each side into the intestine near its commencement (*fo*, Fig. 464.)

777. We know as yet nothing of the manner in which the chyle passes from the intestine into the circulating apparatus. The blood is colourless, or slightly tinged with blue or lilac; and coagulates easily. This liquid is put in motion by a heart, situated on the median line of the back, and composed of but

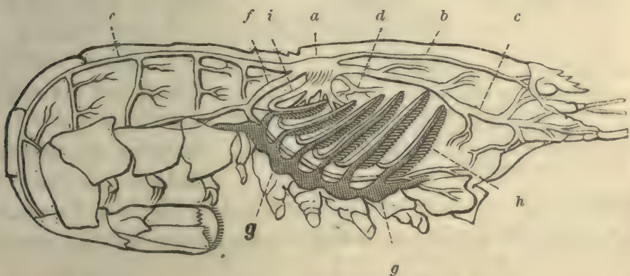


FIG. 465.—CIRCULATING APPARATUS OF LOBSTER; *a*, heart; *b* and *c*, arteries to the eyes and antennæ; *d*, hepatic artery; *e* and *f*, arteries to thorax and abdomen; *gg*, venous sinus; *h*, gills; *i*, branchial veins.

a single cavity of variable form (Fig. 465, *a*). Its contraction propels the blood into the arteries, which distribute it to all parts of the body. The veins are very incomplete, and are formed chiefly by passages left between the different organs, and lined by a thin layer of areolar tissue; they end in large cavities near the base of the legs (Fig 466, *s*,) from which the blood is conducted to the respiratory organs, whence it returns to the heart by very distinct canals termed *branchio-cardiac* vessels.

778. Crustacea are almost all essentially aquatic; their respiration is nearly always effected by gills; and when these organs are absent, their place is supplied by the skin of certain parts of the body, generally of the legs. In other respects, the arrangement of the respiratory apparatus varies considerably. Thus in the Crabs, Cray-fish, and all other Crustacea of analogous organisation, the gills consist of a considerable

number of pyramids,—each composed either of a number of minute cylinders placed like the hairs of a brush, or of little lamellæ piled one on the other like the leaves of a book.—These organs are fixed by their extremities to the inferior border of the arch of the flanks (Fig. 466); and are inclosed in two large cavities, situated at the side of the thorax and shut in between the carapace and the arch just mentioned, an arrangement which is not found in the other divisions of this class. The respiratory cavity communicates with the exterior

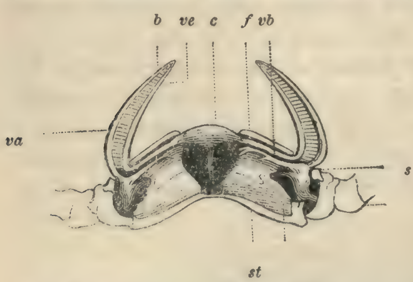


FIG. 466.—VERTICAL SECTION OF A CRUSTACEAN, SHOWING THE COURSE OF THE BLOOD; *c*, heart; *s*, venous sinus; *va*, vessels conducting the venous blood to the gills; *ve*, vessels which collect the aërated blood from the capillaries of the gills; *vb*, branchiocardiac vessels; *f*, carapace; *st*, sternum.

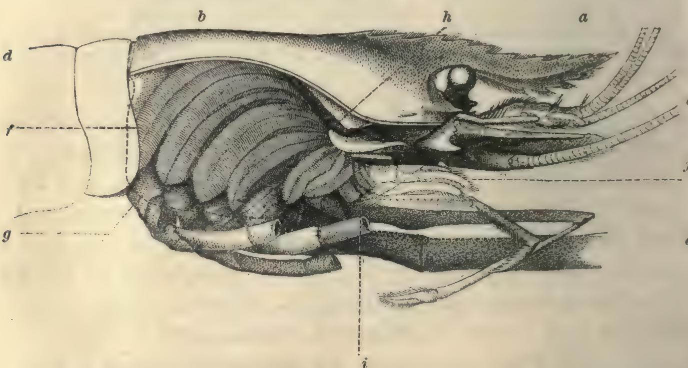


FIG. 467.—RESPIRATORY APPARATUS OF PRAWN; *a*, rostrum or beak; *b*, carapace; *c*, base of antennæ; *d*, base of abdomen; *e*, base of legs; *f*, gills; *g*, dotted line, marking the turned-in border of the portion of the carapace that covers in the gills, which has been removed in this preparation; *h*, canal for the exit of the water from the respiratory chamber; *i*, its valve; *j*, its extremity.

by two openings; that which serves for the entrance of the water is situated between the base of the legs and the side of

the carapace; the other, destined for the exit of the water, is placed at the sides of the mouth (Fig. 467). The renewal of the water in contact with the gills, is effected by the movements of a large valve, situated near this last opening, and formed by lamellated appendages of the second pair of jaws (Fig. 467, *i*). In other Crustacea, the *Scilla* for instance, the gills are formed of feathery tufts; and instead of being inclosed in the thorax,

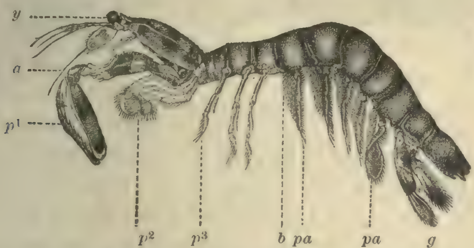


FIG. 468.—SCILLA; *y*, eyes; *a*, antennæ; p^1, first pair of legs; p^2, second pair of legs; p^3, three last pairs of thoracic legs; *pa*, abdominal pro-legs; *b*, gills; *g*, fin-like members.

they float freely on the exterior, and are fixed to the abdominal members. In others, as the Sandhoppers, the gills are replaced by membranous vesicles fixed at the base of the legs, beneath the thorax. Lastly, in the Isopod Crustacea, the respiration is effected by means of false abdominal legs, which present a leaf-like and membranous aspect.

779. A small number of these animals are formed to exist in air; but they constitute an exception to what has been said, relative to the difference in the structure of the breathing apparatus of terrestrial and aquatic animals: for, instead of being provided with lungs or tracheæ, they respire by gills like the former; but these organs are placed in such a manner, as to be surrounded by that degree of moisture, which is necessary for the exercise of their functions. The *Land-Crabs*, which are met with in different parts of the globe, but which chiefly abound in the Antilles, offer a remarkable example of this anomaly. Instead of living in the water like ordinary Crustacea, these animals are terrestrial;

and although provided with gills, some among them are speedily suffocated by submersion in water. Indeed, their respiration is so active, that the small quantity of oxygen dissolved in the water cannot suffice for their wants; but in the air they find this gas in abundance; and an arrangement similar to that which we have met with in certain Fish (§ 538), permits them to remain out of the water without their gills becoming so dry, as to be unfit to perform their functions. Sometimes there is, at the bottom of the respiratory cavity, a sort of basin, destined as a reservoir for the water necessary to supply the requisite moisture to the gills. In other instances, we find in the lower arch of this cavity a spongy membrane, which seems to serve the same purpose. Most of these Land-Crabs commonly inhabit moist woods, and hide themselves in holes which they dig in the soil; but the localities which they prefer vary according to their species. Some dwell in low marshy lands, near the sea; others in wooded hills far from the shore; and these last at certain periods quit their habitual dwellings for the sea. The Woodlice also are terrestrial Crustacea, whose respiration is effected by means of leaf-like plates, which are situated under the abdomen, and which, in other animals formed nearly on the same plan, fulfil the functions of gills.

FIG. 469.—LAND CRAB.

780. All Crustacea are oviparous. The female is generally distinguished from the male by the more enlarged form of the abdomen; and after having laid the eggs, she carries them for some time, suspended under that part of her body, or even inclosed in a sort of pouch, formed by the appendages to the legs. Sometimes the little ones swim about in this pouch, and remain there until they have undergone their first moult. The young do not in general undergo true metamorphoses; but sometimes they acquire, with advancing age, a larger

number of legs; there are some which change their form completely during the first part of their life. This is the case, for example, with the common Crab, whose early condition is represented in the accompanying figure. It is remarkable, however, that in other animals of the same Order, such as the Cray-fish, the change of form is so inconsiderable, as not to deserve the name of metamorphosis. Hence we perceive that the degree of this change cannot be employed as a character in the subdivision of the Class, as we have seen that it may be in Insects. Of a large proportion of Crustacea, however, the early form is unknown. The metamorphoses of some of the lower tribes are even more extraordinary than those of the higher (Figs. 496 and 497, 501 and 502); being frequently such, as appear to remove the adult altogether from the class, to which the larva evidently belongs.

FIG. 470.—EARLY FORM OF THE CRAB.

781. The early condition of many of the higher Crustacea bears a strong resemblance to the permanent forms of the lower. This is in no point more remarkable, than in the character of the respiratory apparatus. Thus in the earliest period of the development of the *Astacus fluviatilis*, or River Cray-fish, no trace of gills can be discovered; but as the embryo within the egg approaches maturity, temporary gills are developed in the form of leaf-like expansions, occupying the situation of the extremities of the maxillary appendages, which are the first developed of all the members. These soon subdivide, and one part assumes a cylindrical form, and seems no longer to belong to the apparatus; whilst branchial filaments begin to appear on the other—which are subsequently prolonged into complete gills. During this interval, the thoracic extremities have made their appearance; and they also become furnished with branchial appendages. At a subsequent time, a narrow groove or furrow is seen along the

under edges of the thorax; the margins of which, after no long period, are prolonged so as to meet each other and enclose the gills,—openings being left for the entrance and exit of water, which are at first large, but which subsequently become contracted to the proper size.

782. The Class of Crustacea may be divided into three natural groups or Sub-Classes, characterised by differences in the conformation of the mouth, as follows:—

I. MAXILLOSA, or *Masticating* Crustacea, whose mouth is furnished with mandibles and maxillæ adapted for mastication.

II. EDENTATA, Toothless or *Suctorial* Crustacea, whose mouth is composed of a tubular beak armed with suckers.

III. XYPHOSURA (so named from the *Sword-like* appendage with which they are furnished, Fig. 505), whose mouth has no appendages peculiar to it, but is surrounded by legs, whose bases perform the office of jaws.

783. The group of MAXILLOSA comprehends the greatest part of the class; and includes all those, whose organisation is most complicated and perfect. These Crustacea do not live on the juices of other animals, as do those constituting the suctorial group; but they are habitually nourished on solid food. They vary greatly in external form, in their number of legs, and in the structure of their respiratory apparatus; and they may be divided by these characters into four Sections, containing nine Orders.—

A. The *first* Section, PODOPHTHALMA, includes all those having the eyes mounted upon foot-stalks, and moveable. They are almost always furnished with distinct branchiæ; their feet are partly formed for walking, and partly for prehension; and the thorax is covered with a *carapace*, formed by the great development of one of the rings. This Section includes the two first Orders:—

I. DECAPODA, possessing five pairs of thoracic extremities, and having the gills enclosed in a special respiratory cavity, on each side of the thorax.

II. STOMAPODA, having the gills external, and a variable number of extremities.

B. The *second* Section, EDRIOPHTHALMA, consists of those Crustacea, whose eyes are *sessile* (that is, not mounted on a foot-stalk), and whose branchiæ are not distinct organs, but are united with the extremities, which are commonly seven on each side, and adapted for walking. This Section contains the three succeeding Orders :—

III. AMPHIPODA, in which the thoracic members are subservient to respiration ; and which have the abdomen well developed, and furnished with six pairs of appendages.

IV. LÆMODIPODA, in which there is the same provision for respiration, but which have the abdomen undeveloped.

V. ISOPODA, in which the abdomen is well developed, and has members, similar in form to the rest, subservient to respiration.

C. The *third* Section, BRANCHIOPODA, is characterised by the absence of any special organs for respiration ; their place being supplied by the flattening of the anterior pair of legs into thin plates, which are subservient to that function. This Section contains two Orders :—

VI. PHYLLOPODA, in which the body is either shell-less, or enclosed in a simple carapace, and furnished with a large number of appendages.

VII. CLADOCERA, in which there is a carapace in the form of a bivalve shell.

D. The *fourth* Section, ENTOMOSTRACA, is composed of Crustacea in which there are no branchiæ, nor any organs destined to supply their place. The eyes are sessile, and are commonly united into a single mass. This Section also contains two Orders :—

VIII. OSTRAPODA, which has the body inclosed in a sort of shield resembling a bivalve shell.

IX. COPEPODA, in which there is no such envelope.

It is in the Order Isopoda, that we find, in the equality of the segments and of their appendages, as well as in the aerial

respiration of many species, the nearest approach to the class MYRIAPODA; and in some members of the Entomostracous section, we find a considerable approximation to the higher ROTIFERA.

SECTION A.—PODOPHTHALMA.

ORDER I.—DECAPODA.

784. In this Order we find the highest general organisation, the largest size, and the most varied habits, which we anywhere meet with among Crustacea ; it is the one most useful to Man ; and also most interesting to the Naturalist. The *Lobsters*, *Crabs*, *Cray-fish*, *Prawns*, *Shrimps*,—in fact, nearly all the species that are ever used as food,—belong to it. Their growth is slow ; but they ordinarily live a long time. Their habits are mostly aquatic ; but, in consequence of the manner in which their gills are inclosed, none of them are killed at once by being withdrawn from the water ; and some of them pass the greatest part of their lives in air. They are naturally voracious and carnivorous : and the first pair of legs is transformed into a pair of powerful claws, by which they seize their food and convey it to the mouth,—the claw of one side usually having a sharp edge for cutting, whilst that of the other is provided with a blunt rounded edge for bruising. The form and size of the claws, relatively to the rest of the extremities, varies greatly in the different species ; thus in the *Cray-fish* (Fig. 471), they only seem like legs somewhat enlarged ; whilst in the *Crabs* (Fig. 475), they commonly seem to be distinct organs. It is in this group, that we find the mouth furnished with the most complicated set of appendages ; and we may trace in these a gradual transition from the form of jaws to that of legs. This is shown in the accompanying figures, which represent the under surface of the Cray-fish, and the series of feet-jaws separately displayed.—This Order is divided into three sub-orders,

according to the development of the abdomen; these are:—I. The BRACHYOURA, or *short-tailed* Decapods, to which the name of *Crabs* is commonly applied;—II. The MACROURA, or *long-tailed*, such as the *Lobster*, *Cray-fish*, &c.;—and III. The

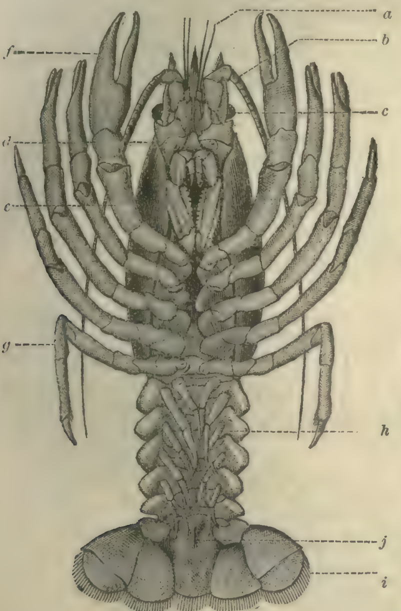


FIG. 471.—CRAY-FISH; *a* and *b*, antennæ; *c*, eyes; *d*, organ of hearing; *e*, external feet-jaws; *f*, first pair of thoracic members; *g*, fifth pair of thoracic members; *h*, abdominal false-legs; *i*, tail-fin; *j*, anus.

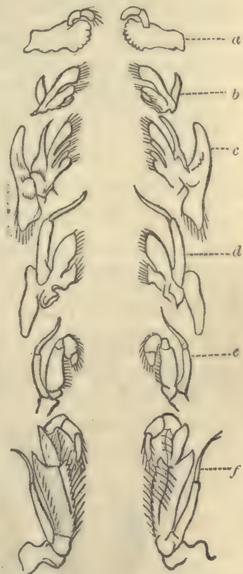


FIG. 472.—MASTICATORY APPARATUS, composed of six pairs of appendages; *a*, mandibles; *b* and *c*, first and second pairs of maxillæ; *d*, *e*, *f*, three pairs of feet-jaws, gradually approaching the form of the ordinary limbs.

ANOMOURA, in which the condition of the abdomen is intermediate. Each of these sub-orders is divided into families; but it will be sufficient here to notice their principal forms.

785. The BRACHYOURA may be considered as ranking at the head of the whole Order, in regard to the concentration and high development of their nervous, circulating, respiratory, and secreting systems. They are formed for walking rather

than for swimming; and they are consequently usually found upon the shore, or even quite inland, rather than afloat. The

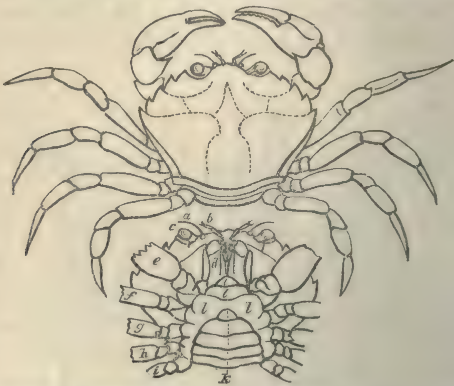


FIG. 473.—CARCINUS MÆNAS, (Common small edible Crab), upper side, and under side of the body with the limbs cut short; *a*, lateral antenna; *b*, intermediate antenna: *c*, eye; *d*, outer foot jaw; *e*, *f*, *g*, *h*, *i*, base of the five pairs of legs; *k*, tail; *l*, sternum.

tail or post-abdomen is shorter than the thorax, and possesses no appendages or swimmerets at its extremity; it is folded in

FIG. 474.—MAIA.

a state of rest beneath the thorax, where it is lodged in a hollow

fitted to receive it; and in the female it is furnished with four pairs of double filaments, analogous to the sub-abdominal swimming appendages of the long-tailed Decapods, and used for carrying the eggs. The claws, or first pair of legs, are alone furnished with pincers; the ordinary legs having only simple pointed terminations.—In the *Maia* (Fig. 474) and other allied genera, the body has very much the form of that of some Spiders, and the legs are very long; whence these Crabs are commonly termed Sea-Spiders by the fishermen.—The *Cancer pagurus*, or common large edible Crab, belongs to a group distinguished by the very great breadth of the carapace, which, in this species, sometimes amounts to as much as twelve inches; it is much arched at the sides, and each border has nine festoons. This

FIG. 475.—CANCER PAGURUS.

Crab is captured, by sinking pots, baskets, or nets, baited with decaying animal matter, to a considerable depth along the rocky coast. During the summer months it is very abundant, especially where the water is deep; but in winter it is rarely to be found, and it is supposed to burrow in the sand, or to retire to the deeper parts of the ocean. The *Carcinus Mænas*, or small edible Crab, is very active in its habits, running with considerable speed; it is caught, however, in large numbers, but is principally eaten by the lower classes, being less esteemed than the preceding as an article of food; its breadth seldom exceeds three inches. There are several other species of this group, which are used as food in different parts of the world, where they take the place of the preceding.—The *Podophthalma*, which is extremely remarkable for the length of its eye-bearing foot-stalks (Fig. 462), belongs to a group of Crabs distinguished by the flattened form of the last pair of legs, which are used as oars, and enable the animal to swim with facility.

786. Of the group of *Brachyourous* Decapods formed to live at a distance from the sea, there are many species; some of them inhabiting fresh water, whilst others form burrows in the ground, even at a distance from water. Of the genus *Thelphusa*, one fresh-water species, a native of the rivers of Southern Europe, was well known to the ancients, who often represented it upon their medals; the Greek monks eat it uncooked, and it is a common article of food in Italy during Lent.

FIG. 476.—THELPHUSA.

Another species, which inhabits India, has been thus noticed by Bishop Heber in his Journal:—"All the grass through the Deccan generally swarms with a small Land-Crab, which burrows in the ground and runs with considerable swiftness, even when encumbered with a bundle of food as big as itself; this food is grass, or the green stalks of rice; and it is amusing to see the Crabs, sitting, as it were, upright, cut their hay with their sharp pincers, and then waddling off with their sheaf to their holes, as quickly as their side-long pace will carry them." They have been found on the table-lands, at an elevation of nearly 4000 feet from the sea; and there is reason to believe that they do not, like the West Indian Land-Crabs, perform an annual migration to the sea, for the purpose of depositing their eggs.—The *Gecarcinus*, or Land-Crab of the Antilles (Fig. 469), is remarkable for its nocturnal and burrowing habits, and for the migrations it executes; when the season arrives for the deposition of the eggs, it moves towards the sea in large companies, taking the most direct line, and seldom permitting any obstacles to interrupt its progress.—Some of the Land-Crabs are remarkable for the inequality in the size of their claws; the larger is used to close up the mouth of the burrows; and it is

sometimes held up in a beckoning attitude, whence these Crabs have acquired the name of Calling-Crabs.—Nearly allied to these, which are all inhabitants of tropical regions, are some small native species, termed Pea-Crabs, which reside, at least during a part of the year, inside various bivalve shells, such as Mussels, &c. The ancients believed that the Pea-Crab lives on the best terms with the inhabitant of the shell in which it is found; and that it not only warns it of danger, but goes abroad to cater for it; this, however, is an absurd fiction.

787. The Decapods of the section ANOMOURA are intermediate between the Short-tailed Crabs, and the Long-tailed Lobsters and Cray-fish; not having the abdomen reduced to the almost rudimentary state, which it presents in the former; neither having it converted into a powerful organ for swimming, as in the latter (Fig. 477). There is nearly always a pair of appendages attached to its last segment; and these have, in some instances, important uses. This section includes the *Hippa* (Fig. 460) and its allies, constituting the family HIPPIDÆ; and also the family PAGURIDÆ, or *Hermit-Crabs*, which are very peculiar as to both their conformation and their habits. The tail, or post-abdomen, is of large size, but its envelope is little else than a membranous bag, entirely unpossessed of the usual hardness of the Crustaceous integument, and presenting no division into segments. The thorax itself is not very firm; and it is only on the claws, which are of large size, that we find the true calcareous envelope. For the protection of their soft tails, the *Paguridæ* resort to various artificial methods. Many of them seek univalve shells, in which they take up their abodes; attaching themselves to their interior by a sucker, with which the tail is furnished at its extremity, and also holding by the three pairs of appendages, or false legs, which it bears at its hinder portion. When they are feeding or walking, the head and thorax project beyond the mouth of the shell; but when they are alarmed they draw themselves in,

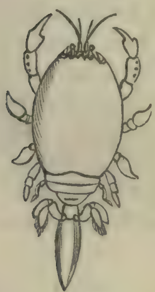


FIG. 477.—REMIPES TESTUDINARIUS.

closing the mouth with one of the claws, which is much larger than the other, and holding to the interior so firmly, that they will rather be torn asunder than quit their attachment. As they increase in size, they are obliged to change their habitation for a more commodious one; and the way in which they accomplish this is very amusing. They may be not unfrequently observed crawling slowly along the line of empty shells, &c., left by the last wave; and as if unwilling to part with their old domicile till a new one has been obtained, they slip their tails out of the old house into the new one, again betaking themselves to the former, if the latter is not found suitable. In this manner they not unfrequently try a large number of shells, before they find one to their liking. There are several species of various sizes, which are inhabitants of our own shores; they feed, for the most part, upon dead fish, and all kinds of garbage thrown upon the shore. The *Birgus*, an allied genus of tropical regions, has the tail somewhat more protected, but still soft; this does not lodge in shells, but retires to rocks, or hides itself in burrows in the earth. The best-known species, *Birgus latro*, inhabits the Isle of France, and lives upon cocoa-nuts; it burrows at the roots of the trees, and feeds upon the fruit which falls from them; and it is even said to climb the trunk, to obtain a further supply.

788. The Macroura, or long-tailed Decapods, are distinguished not merely by the length of the tail, but by having it terminated by a sort of fin, expanded laterally, and consisting of five pieces (Fig. 478). This is a very powerful instrument for motion in water, serving, by its vertical strokes, to propel the animals through the liquid; and we consequently find the Crustacea of this Section much more frequently swimming in the water than walking on its bottom or on the shore. This Section is a very extensive one, and contains the largest species of the whole class. The *Lobsters*, *Cray-fish*, *Prawns*, *Shrimps*, &c., of which the group is chiefly composed, are sufficiently well known to need no description. We may notice, however, the *Palinurus*, or Spiny Lobster, one of the largest animals in the class; which was known to the Romans under the name of Locusta. This is distinguished by the very large size of its

lateral antennæ; which are beset, like the body, with sharp points. The legs are all single-fingered; not even those of the

FIG. 478.—PALINURUS.

first pair being furnished with pincers. This animal frequents deep waters, especially off rocky shores; and it only approaches the coast at the return of spring, to deposit its eggs, which are numerous, minute, and of a bright red colour. The common English species not unfrequently weighs 12 or 14 lbs., when

loaded with eggs.—The *Galathea*, a genus somewhat allied to the preceding, and of which two small species are common on our own coasts, is remarkable on account of the vast numbers in which it sometimes appears; the *Galathea gregaria* having been seen by Sir Joseph Banks, during his voyage round the world, to accumulate in such multitudes, that the surface of the water appeared as if saturated with blood.

Order II.—STOMAPODA.

789. The name of this Order is derived from the mode in which the feet approach the mouth, in many of the animals composing it; not only the foot-jaws, but also part of the thoracic extremities, being directed towards it (Fig. 480). The number of legs is variable; but there are generally from twelve to sixteen,—one or more pairs of the feet-jaws of the Macrourous Decapods being here developed as true legs. The general form of the body bears considerable resemblance to that of the Cray-fish and its allies; the abdomen being much prolonged, the tail-fin much expanded laterally, and the appendages beneath the abdomen being developed and used as fin-feet. There are, however, some considerable differences in their structure; which are quite sufficient to separate the Stomapods as a distinct Order. The branchiæ, instead of being inclosed in a cavity beneath the thorax, are attached to the abdominal appendages, and hang freely in the water (Fig. 468); the heart has more the form and characters of the dorsal vessel of Insects; the integuments have little solidity, and are sometimes membranous and translucent; and the nervous system is arranged in a less concentrated manner.—All the Stomapods are marine; and the largest species are only found in tropical climates. As they are inhabitants of deep waters and the open sea, rather than of the shores, their habits are but little known; but from the conformation of some of the Order, they may be regarded with probability as very voracious.

790. As connecting this Order with the last family of the

preceding, we may first notice the curious genus *Mysis*, or Opossum-Shrimp; which bears, in its general form, so strong a resemblance to the ordinary Shrimps, that it has been usually placed with them. It is distinguished, however, from the true Decapoda, by the external position of its branchiæ; as well as by other characters. In regard to the number of the feet, it holds a very interesting intermediate place between the Decapods and the ordinary Stomapods; for the last pair of feet-jaws is developed into true legs, making their number twelve in all; and the other two pairs have much more the form of ordinary legs, than in the Decapods. Each of the legs has a lateral appendage, which is so much developed as to appear like a second limb; and thus, reckoning-in the feet-jaws, which also possess similar appendages, we may say that the Mysis has no fewer than 32 legs. The common name of this curious little animal is derived from the peculiar conformation, which enables it to afford a special protection to the eggs. The female has a large concave scale, attached to the inner division of each of the posterior legs; and these, overlapping one another, form a pouch, which is capable of being considerably distended. Into this pouch the eggs are received, when they quit the ovarium; and here they continue until the young are so nearly developed, that they present a very close resemblance to the parent. The parent then opens the valves of the pouch, and sets free the whole brood at once into the surrounding element; and these usually seem to remain associated with the community, from which they sprang. Although sparingly distributed in the seas of Europe, these little animals inhabit some parts of the Arctic ocean in amazing numbers; constituting the principal food of the prodigious shoals of Salmon, which resort thither in the months of July and August, and upon which the inhabitants of Boothia depend in great degree for their winter store of provisions; and

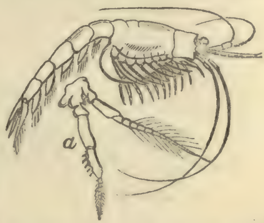


FIG. 479.—MYSIS VULGARIS, about twice the natural length: *a*, one of the bifid legs.

serving also as one of the chief articles, on which the Whalebone Whale is supported.

791. The *Squilla*, which is sometimes termed "Sea Mantis," from the resemblance of its powerful claws to those of that Insect (§ 664), may be regarded as the type of the Order. Its carapace is small, and only covers the anterior half of the thorax;—the posterior being formed of rings like those of the abdomen.

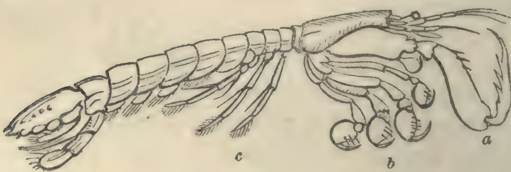


FIG. 480.—SQUILLA MANTIS.

The members which, in their position, correspond with the external feet-jaws of Decapods (Fig. 480, *a*), are here developed into enormous claws, terminating in a sharp hook; in the typical species, *Squilla mantis*, the last joint or finger is furnished with six sharp projecting spines; and the preceding joint, or hand, is furnished with three sharp spines, and is hollowed at its edge into a groove, into which the finger shuts, in such a manner as to render this claw a most efficient instrument of prehension. The other foot-jaws, and the three first pairs of thoracic members (*b*), share in this conformation; being furnished with a sharp moveable finger, and a hand armed with spines, against which the finger closes; and these are directed towards the mouth, in such a manner as to hold the prey against it, in the most efficient manner. The three posterior pairs of legs, which are attached to the annulated (or ringed) portion of the thorax (*c*), are furnished with a brush instead of a hook at their extremities, and more resemble the abdominal swimming legs. The tail is expanded into a broad fin. Thus we see that the locomotive apparatus of this animal is partly adapted for prehension, and partly for natation (or swimming), and not at

all for walking. This species is probably the largest of the Order; its length being about seven inches. It is common in the Mediterranean.

792. To this Order also belongs a very curious genus, the *Phyllosoma*, or Glass-Crab. Its scientific name, which means *leaf-bodied*, as well as its common designation, refer to the remarkable peculiarity of structure by which it is distinguished; the whole body being flattened like a leaf, and almost as transparent as glass. It is composed of a large oval plate, which represents the head, and bears the two eyes, mounted on long footstalks, at its anterior extremity; of a second plate, in part covered by the preceding, and giving insertion to the thoracic legs; and of an abdomen which is always short, and in some species undeveloped. The legs, six in number, are very long and slender; they are bifid or divided into two, like those of the Mysis; and are adapted for swimming only. These curious creatures are inhabitants of the tropical parts of the Atlantic and Eastern Oceans.

793. It is scarcely possible to avoid being struck by the analogy presented by this Order, to the Orthoptera among Insects. The resemblance of the Squilla to the Mantis has already been noticed; and the correspondence of the Phyllosoma to the leaf-like species of the same order (§ 653), is scarcely less remarkable. We may also point out the many resemblances between the Decapod Crustacea, and the Coleopterous Insects. They occupy a corresponding position, in being at the head of the *mandibulate* series of their respective classes; they are both also pre-eminent in regard to the hardness of their integuments; and in both there is an adaptation of the extremities for walking, rather than for swimming or flying—which are actions analogous to each other (ANIM. PHYSIOL., § 663).

Section B.—EDRIOPHTHALMA.

Order III.—AMPHIPODA.

794. Passing on to the group of Edriophthalma,—which is distinguished by the absence of peduncles supporting the eyes, and by the union of the respiratory organs with the locomotive members,—we have to first notice the Order Amphipoda, in which the abdomen is well developed, but the respiratory organs are connected with the thoracic limbs only. These organs consist of membranous vesicles, attached to the base of the legs, of which some traces present themselves in the preceding Order; the continual renewal of the water in contact with them is accomplished by the constant movements of the first three pairs of abdominal pro-legs. The thoracic legs are fourteen in number, consisting of the ten which are characteristic of the Decapods, with the addition of two pairs of feet-jaws,—only one pair of these last organs being here left in its original form. The legs are partly directed forwards, and partly backwards, from which the name of the Order is derived. The abdomen is much developed, and is composed of seven segments,—the last, however, being a mere rudiment; the appendages of the three preceding divisions are often united into a sort of bundle, constituting an organ which is of great service in leaping. These Crustacea are all of small size; but they frequently present themselves in very large numbers. Some of them are inhabitants of the sea and shores, whilst others are abundant in our streams. The greater number of them are very agile leapers.

Fig. 481.—Gammarus Pulex.

795. The common *Talitrus locusta*, or Sand-hopper (Fig. 456),

is a very characteristic example of this Order. It is extremely abundant on our shores; and may often be seen in vast numbers on the sands, especially when the sun is shining upon them and the tide is retreating. The whole surface of the sand, or rather the air for a few inches above it, appears as if alive with them; for they are incessantly leaping to an elevation, which is, for their minute size, very considerable, as if they were in the height of enjoyment. They burrow in the sand; and seldom enter the water. Their food probably consists of the minuter animals, and of the decomposing animal and vegetable remains, which are left in the sand by the sea. The *Gammarus pulex* (Fig. 481), which is nearly allied to the preceding in structure and in its leaping powers, is an inhabitant of fresh water brooks; being especially abundant in those, in which there is an accumulation of decaying vegetable matter. The *Coryphium* is remarkable for its very long antennæ, and for its predaceous habits. It is very abundant on the coast of La Rochelle, where it forms extensive burrows in the sand,—only making its appearance, however, at the beginning of May. It keeps up a continual war with the Annelida, which inhabit the same neighbourhood; and also attacks Mollusca and even Fishes, as well as dead animal matter. Scarcely anything is more curious, than to observe these creatures at the rising of the tide assembled in myriads, moving about in all directions, beating the mud with their arm-like antennæ, and mixing it with water in order to discover their prey. If they meet with Annelids even ten or twenty times their size, they unite together to attack and devour them; and the carnage does not cease, until the whole of the mud has been turned over and examined. It is said that they sever the *byssus*, by which the Mussels are fixed (Fig. 591); so as to cause them to fall, and thus to enable them to be more readily attacked. They are in their turn devoured by Fishes and by many Shore-Birds. The Crustacea

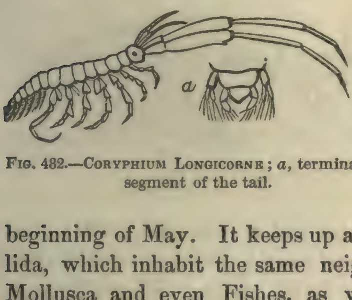


FIG. 482.—CORYPHIUM LONGICORNE; *a*, terminal segment of the tail.

of a portion of this Order are parasitic in their habits ; attaching themselves to the bodies of Fishes ; and having the mouth more adapted for suction.

ORDER IV.—LÆMODIPODA.

796. The Crustacea of this Order resemble the preceding in the conformation of the respiratory organs ; but differ from all the other Edriophthalma, in the want of development of the abdomen. The number of legs varies considerably in the different species. The body is composed (with the head) of eight or nine segments, of which seven may be furnished with members ; but not unfrequently some of the appendages are undeveloped. This Order is divided into two Sections, according to the form of the body ; the *Filiformia*, having the body long and thread-like, and the legs also long and slender (Fig. 483) ; whilst in the *Ovalia*, the body is shorter and broader, and the legs shorter and stouter (Fig. 484). Of the former group, the *Caprella phasma* is a characteristic example ; it is found among marine plants, creeping along in the same manner as the Geometer, or Looper-Caterpillars (§ 700), often bending itself back with great rapidity, and applying its antennæ to various parts of the body. It has five pairs of legs, of which the second is the largest ; these are not disposed, however, in a regular, but in an interrupted series, the second and third segments of the thorax having only the respiratory vesicles. In an allied genus, there are also ten legs, disposed in a continuous series ; and in another, all the fourteen are developed.

FIG. 483.—CAPRELLA PHASMA.

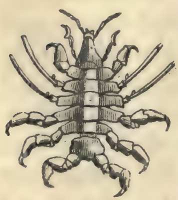


FIG. 484.—CYAMUS BALÆNARUM.

The *Cyamus* and its allies, belonging to the second division of the Order, appear to be mostly parasitic in their habits. The Cyamus, commonly termed the Whale-Louse, attaches itself, by means of its strong claws, to the surface of the body of the Whale; which is sometimes so completely covered by these parasites, that the individuals thus infested may be easily recognised at a considerable distance by their white colour. When the parasites are removed, the skin of the Whale is found to be deprived of its epidermis.

ORDER V.—ISOPODA.

797. These Crustacea bear a general resemblance to the Amphipoda; but their bodies are flattened horizontally, instead of being compressed vertically, and the abdomen is not terminated either by appendages adapted for leaping, nor by an expanded fin for swimming, as in that group. The thorax nearly always consists of seven segments, and is furnished with seven pairs of appendages adapted for walking (Fig. 456); but the respiratory organs are not attached to them, but are developed as expansions of the extremities of the pro-legs, which are attached to the abdominal segments. These organs, which have usually an oval form and a membranous texture, are sometimes suspended freely beneath the abdomen; but they are occasionally covered in by little scales, which fold over and protect them. The females usually have large plates attached to the base of the thoracic legs, which form, by their meeting, a pouch in which the eggs and young are matured; others have a membranous bag in this situation. The newly-hatched young have only six thoracic segments and six pairs of legs,—acquiring an additional segment and pair of legs at the time of their first moult.

798. Of this Order, the principal part is aquatic; but one group is terrestrial. Many of the former are parasitic upon other animals,—very frequently upon larger Crustacea; this is the case with the *Bopyrus*, which is parasitic upon the common Prawn, affixing itself beneath the carapace, upon the branchiæ,

and producing an evident swelling externally. Between eight and nine hundred young ones have been observed beneath the body of a single female; and the parent has the instinct to set them free in situations frequented by the Prawns.—Of those marine Isopods which are not parasitic, the most worthy of notice is the *Limnoria terebrans;* which, although not more than a sixth of an inch in length, is, through its boring habits, and its powers of multiplication, exceedingly destructive. It pierces timber in different directions with astonishing rapidity, apparently for the purpose of feeding upon it, as in its stomach are found minute particles of the wood. It is found in different parts of the British Ocean, attacking wooden piles, immersed in water, in our dock-yards, bridges, flood-gates, chain-piers, &c.; and perforating them in the most alarming manner.

799. It is in the terrestrial species, that we find the most remarkable provision for the inclosure of the respiratory organs; these being completely folded over, by plates developed from the abdominal members; and the anterior plates being perforated with a row of small holes, through which the air gains access to the gills within. Like the Land Crabs, these terrestrial Isopods (of which the common *Wood-louse* is a very familiar example), for the most part frequent damp situations; inhabiting dark and concealed places, such as cellars, caves, holes in walls, the under-side of stones, &c. They feed upon decaying animal and vegetable matter, and come forth from their retreat in damp weather. They crawl slowly, except when alarmed; and they have the power of rolling themselves into a ball, so as to expose on the outside nothing but the plates of the back, and to conceal the appendages of the underside of the body.

FIG. 485.—ANILOCRA.

FIG. 486.—ARMADILLO PUSTULATUS.

800. The order Isopoda is probably the situation, in which we are to place the remarkable fossils known under the name of

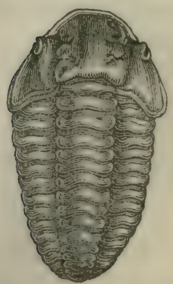


FIG. 487.—CALYMENE BLUMENBACHII.

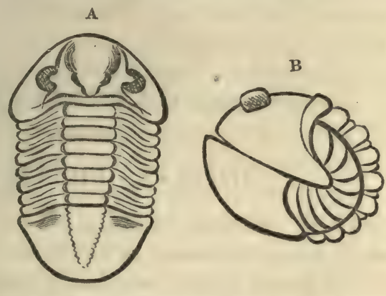


FIG. 488.—A, ASAPHUS EXPANSUS. B, THE SAME ROLLED UP.

Trilobites, from the three lobes into which the body is divided lengthways (Fig. 487). These are found in the very earliest of the formations that contain fossils at all; and they appear to have ceased to exist, before the creation of Mammalia. They resemble the Isopoda in the equality of their segments, as well as in the tri-lobed division of the body, which is presented by some of the recent species of that order; and also in their tendency to roll themselves into a ball (Fig. 488). Their exact situation, however, cannot be known, until some information has been gained in regard to their extremities, of which no remains have yet been discovered. It is probable that these were very short; in which respect they would correspond with those of certain parasitic Isopods; but they may have been soft and membranous, and formed for swimming, like those of the Phyllopoda. They bear no inconsiderable resemblance externally to the *Chiton* among Mollusca (Fig. 584); and could probably, like them, draw the border of the shell completely down to the surface on which they were adherent. Their Articulated character, however, is fully evidenced by the nature of their eyes, which have the compound structure peculiar to that Sub-Kingdom. This has been so perfectly preserved in many specimens, that the facets may be counted with the aid of a magnifying-glass; and as many as four hundred have been found to exist in a single specimen.

SECTION C.—BRANCHIOPODA.

ORDER VI.—PHYLLOPODA.

801. We are now arrived at the third Section of the class,—that of BRANCHIOPODA; in which the union between the legs and respiratory organs, which we have seen to be gradually taking place in the preceding Orders, becomes more complete,—there being now no distinct gills, and the anterior legs being converted into respiratory organs, by an expansion of their surface. Hence the name of the group; which means "gill-footed." In the greater part of this and the succeeding groups, the body is inclosed in a sort of horny shell; which sometimes appears composed of but a single piece, and in other instances is formed like the shell of a bivalve Mollusk:—hence they are commonly known as *Entomostracous* Crustacea (this term meaning, inclosed in a shell). The eyes are generally placed near each other; and are sometimes so close, as to run together (so to speak) into one mass. The foot-jaws are all converted into true legs, being, like them, adapted for swimming; and even the antennæ sometimes become locomotive organs. The number of legs varies greatly; reaching in some species to above a hundred; but being commonly much less. All these animals are aquatic, and most of them inhabit fresh water. They are for the most part extremely active in their habits; and are all of small size, some of them being even of microscopic minuteness. This active locomotion is doubtless in part connected with the act of respiration, and serves to produce a constant interchange in the water in contact with the surface of the body, and especially

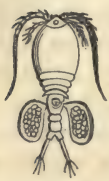


FIG. 489.—CYCLOPS VULGARIS, magnified.

with the branchial expansions of the legs. Even when the animals are at rest, these last organs are seen to be in rapid motion. The eggs are arranged in a mass in a cavity beneath the back of the shell, or are inclosed in a common envelope, and carried in one or two bunches or masses at the base of the tail (Fig. 489).

802. The Order PHYLLOPODA includes those Branchiopoda, whose body, sometimes naked or shell-less, and sometimes inclosed in a shield-like carapace or in a bivalve shell, is divided into a great number of segments, nearly all of which are furnished with leaf-like appendages, or gill-feet. They vary considerably in their conformation ; some of them being provided with a certain number of simple swimming feet, placed behind the gill-feet ; but of the latter there are always at least eight pairs, and sometimes their number amounts to sixty pairs. The first division of the order includes those, which have the body protected by a horny shell. This is the case with the *Limnadia* (Fig. 490), which has a bivalve shell, and bears a considerable

FIG. 490.—LIMNADIA.

FIG. 491.—APUS MONTAGUI.

resemblance to the Daphnia (§ 804), except in the form and number of the feet ; and in the *Apus* (Fig. 491), which has a simple shield-like shell, and in which the feet are very numerous, but all except the anterior ones are extremely small. These last are extremely remarkable for the power which their eggs possess, of retaining their vitality for several years, when the waters in which they are deposited have been dried up. They inhabit lakes, pools, and ditches, and are often found in vast numbers, especially in the spring and beginning of the summer. They are sometimes raised into the air by whirlwinds, and scattered again

like rain. Their eggs are of a red colour, and fall to the bottom of the water, when set free from the egg-cases which the parent bears near its tail. When first hatched, the young differ considerably from their parents, having but one eye, four legs, no tail, and the shell covering only the front half of the body. These little Crustacea are said to feed upon young Tadpoles. They swim well on the back, and burrow in the sand, elevating their tails in the water.

803. In the species included in the second division of the Order, there is neither bivalve shell, nor any trace of a shield-like carapace ; but the body is entirely soft. It is usually much prolonged, and composed of a large number of segments ; but the branchial appendages or gill-feet do not exceed eleven pairs. To this group belongs the curious *Artemia salina*, or Brine-shrimp ; a small Crustacean, about half an inch in length, commonly found in the salt-pans at Lymington, when the evaporation of the water is considerably advanced. The accompanying figures represent the progressive stages of its development. "Nature having constructed it with members solely adapted for swimming, it seems to be in perpetual quest of prey, gliding with an almost even motion through the water, and moving with equal indifference on the back, belly, and sides ; the shape of the animal, the undulating movements of its fins, and the glossy appearance of its coat, render it an object of a very interesting description."—Nearly allied to this is the *Branchipus ;* of which the several species are found, often in great numbers, in small pools, especially after heavy rain ; sometimes even in those which are left on the uneven surfaces of stones,—the eggs, which are inclosed in a strong shell, seeming

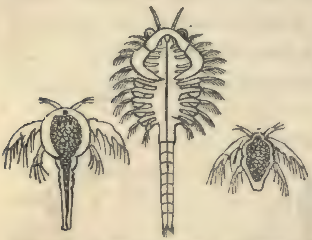


FIG. 492.—ARTEMIA SALINA, in different stages.

FIG. 493.—BRANCHIPUS STAGNALIS.

to have been transported by the wind. The *Branchipi* generally swim on their backs; and their short lamellar feet, which are unfit for walking, are then kept in an undulatory motion, that sends forward a current of water, along a channel hollowed in the lower side of the body, to the mouth, and thus supplies the animal with food. At other times, they swim more forcibly, by alternate lateral strokes of the tail upon the water.

Order VII.—CLADOCERA.

804. The Order Cladocera consists of those minute Crustacea answering to the foregoing description, which have the body inclosed in a bivalve shell. These belong, for the most part, to the genus *Daphnia;* of which the common species, *Daphnia pulex* (which has also received the name of *Monoculus* from its single eye), is commonly termed the Arborescent Water-Flea, from its power of leaping, and from the branching form of its antennæ, which serve as oars. It is very abundant in many ponds and ditches, coming to the surface in the mornings and evenings, and in cloudy weather; but seeking the depths of the water during the heat of the day. It swims by taking short springs, and feeds on minute particles of vegetable substances, not however rejecting animal matter when offered. There are several curious points, relative to the propagation of these little animals, which are worthy of notice. After the eggs leave the ovaries, they remain in a large cavity between the body and the shell; here they usually attain their complete development,—the young coming forth into the world, in a form very nearly resembling that of the parent. From the transparency both of the eggs and of their containing envelope, the whole process of development may be distinctly seen. At first the eggs are quite round, and seem as if made up of a multitude of minute globules. The shape then alters a little, becoming oval; and these globules augment in number; but as yet no trace of any body is perceptible. A little afterwards, we see a black spot in the centre, which is the eye, and which is the first organ visible.

The other organs then begin to show themselves; but it is not until near the end of the fourth day, that any motion is perceptible. They come forth into the world, at the end of the fifth day, with the tail curved up within the shell; and very shortly after birth, this tail may be seen to spring forth with a sudden jerk, and to assume its natural position. In a short time afterwards, the animal acquires the perfect form, and it speedily increases in size,—throwing off its envelope, and acquiring a new one, at short intervals. In summer these moultings are frequently seen to be performed every two days; but in colder weather, several days elapse between them. They do not cease with the full growth of the animal, but continue during its whole life. The purpose of this may be, to prevent the animal being injured by the tendency of its shell to become overgrown with parasitic Animalcules and Confervæ; for weak and sickly individuals may be frequently seen so covered with these growths, that their motion and life are soon arrested, the animals apparently not having strength enough to throw off their envelope.

805. After the third or fourth moulting, the young Daphnia begins to deposit its eggs in the cavity of its back; these may be frequently seen there, as early as the tenth day of its separate existence. Soon after the young are born, another moulting takes place; and the egg-coverings, which have been left in the cavity, are thrown off with the shell. In a very short time afterwards, another brood of eggs is seen in the cavity; these are soon hatched, and another moult takes place; and these processes continue to take place through the whole season, until the weather becomes severe. All the *Daphniæ* then seem to be destroyed; none having their existence prolonged through the winter. There is, however, a very curious provision for perpetuating the race. At particular seasons, the *Daphniæ* may be found with a dark opaque substance on the back of the shell. This has been termed the *ephippium*, from its resemblance to a saddle. When examined by the microscope, it is seen to be of a dense texture, and to be composed of a mass of hexagonal cells; and to contain two oval bodies, which are capsules opening like a bivalve shell, each inclosing an ovum covered with a horny

envelope. This is first seen after the 3rd moulting; after the 4th it passes into the open space in the back; and at the 5th it is thrown off with the shell, and remains floating on the surface of the water, until the temperature rises sufficiently to hatch the eggs. The ephippial eggs which are deposited in the summer are probably developed during the same season; but those which are laid in the autumn remain undeveloped during the winter, being protected by their peculiar envelopes; and it is by the action of the returning warmth of spring upon them, that the new generation of Daphniæ is produced in the next year. They may be at any time hatched, however, by artificial warmth. "These two species of eggs," says an attentive observer of the processes now described, "produced by the same being, offer a very singular example in the history of animals, and show with what wisdom Nature provides for the preservation of even her smallest creatures."

806. The *Polyphemus* has, like the Daphnia, oar-like antennæ, divided into two branches. It is remarkable for the large size of its head, which is almost entirely occupied by a single enormous eye (Fig. 494.) It swims on its back or sides, giving to its antennæ and legs quick and repeated motions, and executing with the greatest ease all kinds of evolutions.

FIG. 494.—POLYPHEMUS STAGNORUM, magnified.

SECTION D.—ENTOMOSTRACA.

ORDER VIII.—OSTRAPODA.

807. We are now arrived at the last group of Masticatory Crustaceans; in which we lose all trace of organs peculiarly adapted for respiration,—the feet not being modified for this purpose, as in the last Section, but being expressly formed for swimming, each member being terminated by two oars composed

of two or more joints. There is considerable resemblance, except in the conformation of the mouth, between some of these and the *Suctorial* Crustacea hereafter to be described. It is to this group, that the term *Entomostracous* has been restricted by later Naturalists; but it is commonly applied to the minute Branchiopodous Crustacean just described, and even to the *Limuli* (§ 816), as well as to these—all agreeing in the inclosure of the body in a single or bivalve shell.

808. In the Order Ostrapoda, the body does not exhibit a division into distinct rings, and is altogether inclosed between the two valves of a bivalve shell. This shell is furnished with a hinge, like that of a bivalve Mollusk; and can be closed in such a manner as to envelop the animal completely; but the valves are in general sufficiently wide apart, to allow the extremities of the antennæ and feet to pass out between them. There are two pairs of antennæ; of which the first (*a*, Fig. 495) is slender, whilst the second (*b*) is large, directed downwards, and adapted for swimming. The mouth is situated near the middle of the inferior surface of the body; it is furnished, besides an upper and lower lip and a pair of mandibles, with two pairs of maxillæ; of which the posterior carries a large flapper-like appendage, that is probably to be regarded as a branchial organ. The true thoracic feet are only four or six in number. The body terminates in a bifid tail; and the eggs are lodged, as in the Daphniæ (to which these animals bear a strong general resemblance), in a cavity between the back and the shell. The principal genus of this Order is the *Cypris*, which, like the Daphnia and the Branchippus, is an inhabitant of pools and streams; and strongly resembles the former of these, in regard to its moultings and the deposition of its eggs. The young are not born alive, however; for the mass of eggs, including about twenty-four, is attached by the female to water-plants, with the aid of a glutinous secretion,—an operation which lasts about twelve hours. There are but two pairs of legs in this genus, of which the posterior does not make its appearance outside the shell; being bent upwards

Fig. 495.—Cypris Vidua, magnified.

to give support to the ovaries. The food of these little animals consists of dead (but not putrid) animal matter, confervæ, &c.; but they will not attack living animals that are well and strong, although they are often seen to attack worms, &c., when wounded and weak, and even to prey on one another. When the ponds and ditches in which they live dry up in summer, they bury themselves in the mud, and thus preserve their lives as long as the mud retains any moisture,—becoming as active as ever when the rain falls, and again overflows their habitations. After long-continued droughts, however, when the mud becomes very dry and hard, they perish ; but the race is then kept up by the eggs, which are capable of resisting this influence. These little creatures are very lively; being almost constantly seen in motion, either swimming by the united action of their antennæ or anterior feet, or walking upon plants and other solid bodies floating in the water. When alarmed, they draw their antennæ and legs within the shell, and close its valves so firmly, that there is no possibility of opening them. An allied genus, *Cytherina*, distinguished by the possession of three pairs of legs, is an inhabitant of salt water.

809. There is abundant evidence of the former existence of the minute Crustacea of this group, to an enormous extent; and their size was much greater. The largest existing species of Cypris does not exceed one-sixteenth of a line in length. But in certain strata of the Secondary and Tertiary formations, which appear to have been deposited by fresh water, we find layers, sometimes of great extent and thickness, which are almost entirely composed of the fossilized shells of Cyprides, many of them exceeding a line in length; and in the Chalk, which was a marine deposit, the remains of bivalve Crustacean shells, probably belonging to the genus Cytherina, are frequently to be found in great abundance.

ORDER IX.—COPEPODA.

810. The Entomostraca of this Order bear a strong resemblance in the general form of their bodies to the Edriophthalma; they have no carapace, nor bivalve shell, like that of the last Order; and their envelope is of membranous or soft consistence. The head is large, and distinct from the thorax; and the body is distinctly divided into several segments, of which the thorax presents from three to five, and the abdomen two or more. The number of legs is always at least eight or ten; and the abdomen is terminated by a bifid tail adapted for swimming. The first pair of antennæ is long, slender, and many-jointed; those of the second pair are sometimes wanting, and sometimes developed into swimming-legs. The mouth is furnished, besides the mandibles and maxillæ, with two or three pairs of feet-jaws; of which the posterior are usually very large, and furnished with a set of feathery bristles, which almost cover the remainder of the buccal apparatus. In one division of the Order, we find the two eyes quite distinct; in the other they form but a single mass on the median line. The eggs are contained, when they quit the ovarium, in two capsules borne at the base of the tail (Fig. 489); and the young, when they first emerge from them, present a form differing greatly from that of the parent, which is only attained after several moults (Figs. 496, 497). The *Cyclops* is a very common genus of this Order; belonging, as its name implies, to

FIG. 496.—LARVA OF THE CYCLOPS.

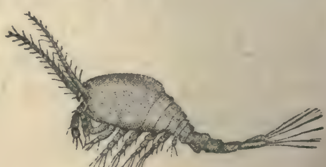


FIG. 497.—CYCLOPS.

the single-eyed division of it. This genus contains numerous species; of which some belong to fresh water, whilst others are

marine. The fresh-water species abound in the muddiest and most stagnant pools, and often too in the clearest springs ; the ordinary water with which London is supplied frequently contains great numbers of them. The marine species are to be found, often in immense abundance, in small pools on the sea-shore, within high-water mark, living among the sea-weeds and corallines; and others inhabit the open ocean, where, by the luminous properties they possess, they assist in producing its phosphorescence. Their vast numbers are the less surprising, when the extraordinary rapidity of their multiplication is known. It has been calculated by Jurine, who attentively observed their habits, that from one female, 4,442 *millions* of young might be produced in a year. The time occupied in the transformations and development of the young, varies according to the season; and this variation appears to depend, according to the experiments of Mr. Baird,* not only on temperature, but also on the degree of *light*, the metamorphosis being retarded by darkness, as in the Batrachia (§ 483). The Cyclops is carnivorous, feeding upon Animalcules that are brought to the mouth by the action of the feet-jaws, which create a whirlpool in the surrounding water; and in this manner they even devour their own young. In their turn they fall victims to the larvæ of aquatic Insects, the Water-spiders, and other aquatic animals, which thus restrain their multiplication within due bounds. Owing, probably, to the softness of their envelopes, they do not resist drought as well as many other Entomostraca; but they seem capable of resisting almost any degree of cold, and they have been immersed for some time in spirit of wine, without losing their vitality.

811. All these minute Entomostraca furnish very interesting objects for Microscopic examination; and the study of their development and habits will abundantly repay the most diligent observation. Except during the winter, there is probably not a pool of water in this country, that does not contain some species of them.

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* "Magazine of Zoology and Botany," Vol. I., p. 316. A large proportion of the facts here stated respecting these and other Entomostraca, are derived from Mr. Baird's highly interesting and valuable papers in that journal.

812. We next pass to the Sub-Class of *Suctorial* Crustacea, in which the mouth, instead of being furnished with mandibles and maxillæ adapted for the division of solid aliment, is prolonged into a beak, and can only receive liquid substances. Still among the Crustacea, as in Insects, the parts which compose the Mandibulate mouth of the preceding Orders, may be recognised in the Haustellate or Suctorial mouth of those we have now to consider. The proboscis is formed by a prolongation of the upper and lower lip; and it is generally accompanied by a pair of long appendages, which evidently correspond with the mandibles of the preceding Orders, and which serve to make the punctures into which the proboscis is inserted. Other appendages, found at its base, are the representatives of the maxillæ and feet-jaws of the Mandibulate Orders; and these are frequently developed as hooks, by which the animal attaches itself to its prey. Many of the Suctorial Crustacea bear a strong resemblance in their general form to the Cyclops and other Copepoda. The body is usually divided, at its anterior part at least, into distinct segments; and there are generally four pairs of legs, each furnished at its extremity with two oar-like expansions. The resemblance is often strongest in the early stages of development; —the young *Lernæa*, for example (Fig. 502), being scarcely distinguishable from the young *Cyclops* (Fig. 496). But in their advance towards maturity, the Suctorial Crustacea frequently undergo the most extraordinary changes; so that, if we were to attend to their adult forms alone, we should be tempted to exclude them from the class altogether,—in so small a degree do they present its distinguishing characters. This group is divisible into three Orders; of which the first two are parasitic, and the last free.

X. Siphonostoma. In this Order, the mouth is armed with styliform mandibles; the thorax is composed of several distinct joints, and bears three or four pairs of swimming-feet; and the feet-jaws are well developed.

XI. Lernæida. The mouth in this Order, as in the preceding, is armed with piercing mandibles; but the thorax exhibits no division into segments; and both the feet-jaws and the true legs are undeveloped.

XII. ARANEIFORMES. This very curious group, which was formerly ranked among the Arachnida, has the feet adapted for walking, and well developed; but the mouth is unpossessed of distinct mandibles.

ORDER X.—SIPHONOSTOMA.

813. The Crustacea of this Order are all parasitic upon Fishes, aquatic Batrachia, &c.; and many of them are known under the name of Fish-lice. Their general characters may be understood from those of the two genera *Argulus* and *Caligus*, which will be briefly described. The *Argulus* has its body covered with an oval shield, which does not extend, however, over the posterior part of the abdomen. There are four pairs of legs, somewhat resembling those of the Branchiopoda, and adapted for swimming. The tail also is a kind of swimmeret. On each side of the beak or proboscis, there is a large short cylindrical appendage, terminated by a curious sucking-disc; and there is also a pair of larger jointed members, terminated by prehensile hooks. These two pairs of organs, enabling the animal to attach itself firmly to that on which it lives, are probably the representatives of the feet-jaws. The eggs of the Argulus are deposited upon floating bodies, like those of the Cyclops; and the young, when they first come forth, bear a strong resemblance to those of that genus. Their swimming organs consist of the oar-like antennæ and feet-jaws; the true swimming legs, and the suckers and hooks on the feet-jaws of the adult, not making their appearance until after several moultings. These Crustaceans may be regarded as in several respects intermediate between those of the preceding Order, and the true Suctorial Crustacea; for they have, even in the adult state, much more locomotive power than the generality of the latter; and are not unfrequently met with swimming freely in the water.

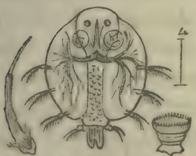


FIG. 498.—ARGULUS FOLIACEUS. 1, the animal magnified; 2, one of the large anterior sucking-feet, 3, the siphon; 4, natural length.

814. The *Caligus* (Fig. 499) is much more strange in its form

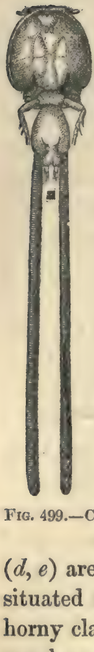


FIG. 499.—CALIGUS.

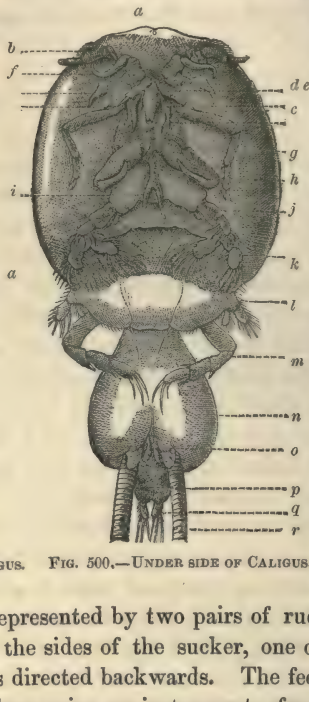


FIG. 500.—UNDER SIDE OF CALIGUS.

Its body is composed of two principal portions ; the anterior one covered by the oval shield or carapace (Fig. 500, *a*) ; the posterior, forming the termination of the thorax and the rudimentary abdomen, is divided into rings. The first pair of antennæ is reduced to the condition of small flattened plates, in some species bearing a sucker. The antennæ of the second pair (*b*) also are short, and composed of only two joints. At *c* is seen a sucker, formed by the labrum, and inclosing the mandibles. The maxillæ (*d*, *e*) are represented by two pairs of rudimentary appendages, situated at the sides of the sucker, one of them terminated by horny claws directed backwards. The feet-jaws (*f*, *g*, *h*), to the number of three pairs, are instruments of prehension, by which the animal attaches itself ; and behind the last pair of these, there is a forked appendage on the central line (*i*), which probably assists in the same object. There are four pairs of thoracic legs ; of which the first three (*j*, *k*, *l*), formed for swimming, are situated beneath the carapace ; whilst the last (*m*), which comes forth behind it, is rather adapted for walking. The abdomen forms but a single segment (*p*) ; and is furnished with a pair of small fin-like appendages (*q*). One of the most curious parts in the structure of this animal, is the pair of long tubes (*r*), which are attached to the sides of the abdomen of the female ; these appear to be receptacles for eggs, and to be analogous to the capsules of the Cyclops, &c. (Fig. 489).

Order XI.—LERNÆIDA.

815. The animals of this Order depart so widely from the ordinary form of the Crustacea, that, until their early state was known, they were ranked among the lower Articulata. In their adult state, there is an almost complete absence of members or appendages; and those which remain are destitute of joints, being merely fleshy lobes serving to attach the animal to the surface of that on which it lives. They all bear a more or less close resemblance to the *Lernæa*, an animal which is not unfrequently found on the eyes and gills of Fish. The form of the adult is displayed in Fig. 501; which shows its long suctorial trunk or proboscis (*a*); its short thorax (*b*), bearing the pair of legs (*c*), by which the animal is attached; its large abdomen (*d*), and its two egg-capsules (*e*). The legs are united to each other at their extremities; and bear a kind of sucker (*f*), which is applied to the surface attacked by the animal, and assists in retaining it there. The whole anterior part of the body, however, is usually buried in the substance of the part, from the juices of which the Lernæa derives its nutriment.—However dissimilar the form and characters of this creature appear, to those of even the preceding group, yet its connection with them is made evident in two ways. In the first place, there are numerous parasitic species, which depart less from the ordinary type; forming a gradual transition from the Suctorial Crustacea of the last order, to the highly-aberrant form presented by the Lernæa; so that, if the latter is excluded, it would be difficult to say where the line is to be drawn. And again, the early forms of the Lernæa (Fig. 502) so strongly resemble those of the Cyclops and other

Fig. 501.—Lernæa.

Fig. 502.—Larva of the Lernæa.

Entomostracous Crustacea (Fig. 496), that it would be impossible to show any decided difference between them. This is a very interesting example of the importance of becoming acquainted with the whole Natural History of an animal, whose place in the scale is at all doubtful.

ORDER XII.—ARANEIFORMES.

816. This is a very remarkable group, which is only referred to the position here assigned it, because it can scarcely be placed in any other,—at least without a more exact knowledge of its internal structure and development. It consists of the small family PYCNOGONIDA ; which, in regard to the general form of the body, and the completeness of the extremities, seems to take rank rather with the higher Crustacea, or with the Arachnida. With the latter they have been commonly associated, on account of the number of their legs ; but they differ in the absence of breathing pores, by which the want of internal respiratory organs may be inferred ; and in their marine residence. There is reason to believe that the digestive cavity is not confined to the narrow body ; but that it sends prolongations into the legs,—as it does into the rays of the Star-fish ; and from this circumstance, as well as from the absence of a respiratory apparatus, the circulating system may be regarded either as incomplete, or as altogether wanting,—the respiration being provided for, as in the lower tribes of Crustacea, by the exposure of the fluids of the body to the surrounding medium. Further, the residence of these animals would seem to remove them from the Arachnida ; for they are all marine, many being found amongst plants or stones on the sea-beach, and others being dredged up from deep water. Their minuteness renders it difficult to ascertain many points of their structure ; and much is still to be learned respecting them. Various species exist on our own coasts. Their motions are remarkably slow and apparently difficult ; and it is obvious from this circumstance,

FIG. 503.—PYCNOGONUM BALÆNARUM.

as well as from the conformation of the mouth, that their prey must consist of either dead animal matter, or of living animals as defenceless as themselves. The females are distinguished by the possession of a pair of spurious legs (Fig. 504), placed in front of the rest, and appropriated to the purpose of holding and carrying the eggs. These are collected into globular masses, enveloped with a thin skin or membrane, each mass being firmly adherent to the limb. There are several of these masses in most species of the tribe; but in *Pycnogonum* itself, the eggs form a single broad square membrane laid under the body.—The proboscis of these curious animals, which seems to refer them to the group of Suctorial Crustacea, is really the entire head; and the organs which have been usually described under the name of palpi and mandibles, as appertaining to it, are in reality appendages of the thorax, and must be considered as metamorphosed legs; so that the Pycnogonidæ really have seven pairs of legs, like the Crustacea to which they are most nearly allied.

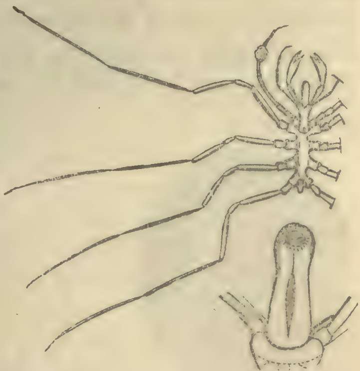


Fig. 504.—Nymphon grossipes, and under side of its Beak.

There now only remains to be considered the third sub-class of the Crustacea; which consists of but a single Order.

Order XII.—XYPHOSURA.

817. Although this group only contains a single genus, the *Limulus*, or King-crab, yet the structure of this departs so widely from that of all the Crustacea we have hitherto considered, that it cannot be referred to the same Order, or even

the same Sub-Class, with any of them. The Limuli,—which are Crustacea of considerable size, sometimes attaining the length of two feet,—have their bodies divided into two parts; of which the anterior, covered by a large semicircular shield (*e*, Fig. 506), bears the eyes, the antennæ, and six pairs of legs, which surround the mouth (*b*), and are used both for walking and for

Fig. 505.—Limulus.

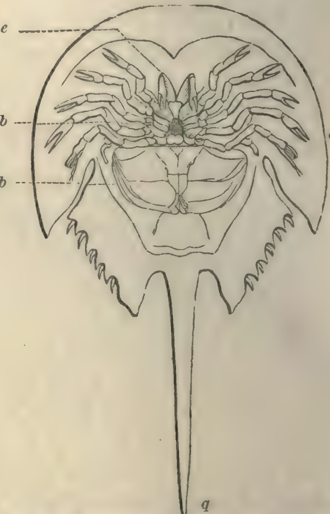


Fig. 506.—Under surface of Limulus.

mastication; whilst the posterior portion of the body, which is covered by another shield of a somewhat triangular shape, bears on its under surface five pairs of swimming legs, of which the last is furnished with gills; and this triangular shield terminates in a long pointed process (*q*). Now when we compare the appendages to the head and body of these animals, with those of ordinary Crustacea, it is evident that the first pair of the legs surrounding the mouth of the Limulus represents their mandibles; that the second and third pairs represent their maxillæ; the three following pairs of legs their feet-jaws; and the five pairs of swimming-members, abdominal fin-feet,—the true thoracic legs being altogether absent. Besides the pair of compound eyes, characteristic of the Crustacea in general, the Limuli have a pair of small simple eyes, placed anteriorly, near

the central line.—The Limuli are confined to the shores of tropical Asia, the Asiatic Archipelago, and tropical America. As the best-known species comes from the Mollucca Islands, they are sometimes termed Molucca Crabs. Of their habits very little has been ascertained. They appear to prefer the neighbourhood of sandy shores, and it is said that when kept from the water, they bury themselves in the sand, in order to avoid the violent heat of the sun, which causes them speedily to perish. They feed upon animal flesh. The long horny process of the posterior shield is not developed in the young animal; which also wants the posterior or branchial members. This process is used by some of the Malays as a point for their arrows; the wounds it makes being dangerous, like those made by the spines of many Fishes, on account of their jagged character. On the coast of America, where the Limulus is known as the Casserole Fish, the shell is employed as a ladle for water.—Fossil remains of this genus are not uncommon in the Secondary and Tertiary strata; and it may be further remarked that, in several particulars, the *Trilobites* may be regarded as having been probably analogous to it.

Geographical Distribution of Crustacea.

The extensive study of this large and important class, by M. Milne-Edwards, has enabled him to arrive at some very interesting conclusions in regard to its Geographical Distribution. An outline of these will be here introduced, because they would probably serve, with some modifications, to represent the general facts relating to the distribution of other Classes.

818. It has been pointed out, in the preceding sketch of the principal forms of the Crustacea, that different species have different localities, or residences assigned to them (as it were), on the surface of the globe. We have seen that some are exclusively confined to fresh water,—that others are inhabitants of the brackish water of estuaries,—that others take up their abode on the shore, where they are periodically covered and left dry by the tide,—that others frequent the shallow waters in the neighbourhood of the shore,—that others are found near the bottom of the deeper waters, at no great distance from land,—that others,

again, roam freely through the open sea,—and finally, that others are only to be met with on the dry land, at a considerable distance from the shore. Thus we see that each species has an appropriate *kind* of residence, for which it is peculiarly adapted by its organisation and habits; but it may be further stated, that each species has an appropriate *place* of residence, which is very much determined by the temperature of the region. It is true that there are many species very extensively distributed; but this results from their being adapted, by some peculiarities of structure and habit, which we cannot detect, to sustain life under a considerable variety of external conditions (§ 13). The extent to which even these species are distributed, however, will depend, in great part, upon the locomotive powers with which they are endowed, either in their adult or their young states; and also (in regard, at least, to all but the freely-swimming marine species) to the continuity of *a line of coast*, from one point to any other, along which their migrations may be effected. The existence of constant or periodical currents, too,—such as the Gulf Stream of Mexico,—will often affect the distribution of species; thus it is probably to this cause, that we are to attribute the presence of some American Crustacea on the shores of the Canary Islands.

819. The following are the general principles arrived at by M. Milne-Edwards in regard to the influence of *Temperature* on the Geographical Distribution of Crustacea.

I. *The different forms and modes of organisation of these animals manifest themselves more, in proportion as we pass from the Polar Seas towards the Equator.*—Thus, on the coasts of Norway, where there is frequently a vast multiplication of *individuals* of the same species, the number of *species* is very small; but the latter increase rapidly as we go southwards. Thus the number of species of Crustacea of the first two Orders, known to exist on the coast of Norway and the neighbouring seas, is only sixteen; but eighty-two are known to be inhabitants of the western shores of Britain, France, Spain, and Portugal; one hundred and fourteen are known in the Mediterranean Sea; and two hundred and two in the Indian Ocean. A similar increase may be observed in following the coast of the New World, from Greenland to the

Caribbean Sea; the number of species of Decapods in the former region being only twelve, whilst in the latter it is seventy-one.

II. *The differences of form and organisation are not only more numerous and more characteristic in the warm than in the cold regions of the globe; they are also more important.*—The number of natural groups, which we find represented in the Polar and Temperate Regions, is much smaller than that of which we find types or examples in Tropical Seas. In fact, nearly all the principal forms, which are met with in colder regions, also present themselves in warm; but a very large proportion of the latter have no representatives among the former. Thus, of the three primary groups, into which the Class is at first subdivided, the Xyphosura are altogether wanting beyond the forty-fourth degree of latitude. Again, the Brachyourous and Anamourous Decapods appear to be altogether excluded from some of the most northern regions that have been explored. Of the family of Squillidæ (§ 791), so highly characteristic of the Order Stomapoda, it is rare to meet with any members, north of the forty-fifth degree of latitude. And the curious group of Phyllopoda is restricted within a still nearer neighbourhood of the Tropical Region.

III. *Not only are those Crustacea, which are most elevated in the scale, deficient in the Polar Regions; but their relative number increases rapidly as we pass from the Pole towards the Equator.* Thus the Brachyoura, which must be considered as the most elevated of the whole series, are totally absent, as we have just seen, in some parts of the arctic region; and we find their place taken by the far less complete Edriophthalma, with a small number of Anomourous and Macrourous Decapods. In the Mediterranean, however, the Decapods surpass the Edriophthalma in regard to the number of species; and the Brachyourous division predominates over the Macrourous, in the proportion of two to one. And in the East and West Indies, the short-tailed are to the long-tailed Decapods, as three, four, or even five, to one.—Again, the *Land-Crabs,* which are probably to be regarded as taking the highest rank among the Brachyoura, are only to be met with between the tropics. And of the *fluviatile* Decapods (those which inhabit rivers, brooks, and lakes), a large proportion belong in tropical regions to the elevated type of the Brachy-

oura; whilst all those found in the temperate and arctic zones belong to the Macrourous division.

IV. When we compare together the Crustacea of different parts of the world, we observe that *the average size of these animals is considerably greater in tropical regions, than in the temperate or frigid climes.* The largest species of the arctic and antarctic seas, are far smaller than those of the tropical ocean; and they bear a much smaller proportion to the whole number. Further, in almost every group, we find that the largest species belong to the equatorial regions; and that those which *represent* them (or take their place, as it were) in temperate regions, are of smaller dimensions.

V. It is where the species are most numerous and varied, and where they attain the greatest size,—in other words, *where the temperature is most elevated,—that the peculiarities of structure, which characterize the several groups, are most strongly manifested.* Thus the transverse development of the cephalo-thorax, which is so remarkable in the Brachyourous Decapods (the *breadth* of the carapace of the typical Crabs being much greater than its length from back to front), is carried to its greatest extent in certain Crustacea of the Equatorial region; and the same might be stated of the characteristic peculiarities of most other natural groups. Further, it is in this region that we find the greater part of those anomalous forms, which depart most widely from the general structure of the Class.

VI. Lastly, *there is a remarkable coincidence between the temperature of different regions, and the prevalence of certain forms of Crustaceous animals.* Thus there are few *genera* to be met with in the West Indian seas, which are not represented in the East Indian,—the *species*, however, being usually different. The same may be said of the genera inhabiting the temperate regions of the globe;—similar generic forms being usually met with in the corresponding parts of the Old and New World, and of the Northern and Southern Hemispheres, although the *species* are almost invariably different.

CHAPTER XI.

OF THE CLASS OF MYRIAPODA.

820. The Class Myriapoda is the lowest in which we meet with articulated members, or distinct jointed legs, as well as with an articulated body. These legs are intermediate in conformation between the more highly-organized legs of Insects, and the simple bristle-like appendages possessed by some of the Annelida; and this is exactly the place to which we should refer the animals of this class, from a regard to their general structure. For, on looking at the form of their bodies, we see that they are distinguished by a uniformity in the character of their segments, nearly as great as that which prevails in the Annelida; so that an Iulus (Fig. 511) might almost be likened to an Earthworm, provided with a stiffer integument and with slender legs:—whilst, on the other hand, the adaptation of the respiratory organs to breathe air with regularity and energy, the complexity of the masticating apparatus, the possession of distinct eyes, and many other characters, indicate their affinity with Insects; in which class, indeed, some Naturalists comprehend them. They differ from insects, however, not merely in the absence of wings, but in the great multiplication of the segments, which are nearly always twenty-four at the least, each provided with a pair of legs; and also in the absence of any line of division between the thorax and abdomen. As we have already seen (§ 797), there are certain Crustacea which bear a considerable resemblance to them in regard to the equality of the segments, and general organisation; but these are characterized by their *branchial* respiration, and the number of their segments is usually much inferior.

821. The covering of the body of these animals is firm, and of a somewhat horny character, resembling that of many Insects. The division into segments is very distinct; a flexible membrane

being interposed between each pair of firm rings or plates. This is obviously required by the condensation of the rest of the integument; since, if it were otherwise, the body would not have the power of bending in any direction. The legs are covered with the same kind of integuments, and are jointed in a similar manner; each terminates in a single claw or hook. Sometimes two pairs of legs seem to be present on each segment (Fig. 507); but this results from the fact, that two adjacent segments are soldered (as it were) together, so as to appear but one, —as is made evident by the existence of a similar *doubling* of all the other organs in each division, and by the existence of a deep groove which runs across it, marking the line of union. The first segment or head is furnished with a pair of compound eyes, resembling those of Insects, but less complicated in their structure; and also with a pair of jointed antennæ. The mouth is adapted for mastication; and possesses a pair of mandibles, followed by a lower lip, and by a pair of appendages somewhat resembling the feet-jaws of Crustacea. On the side or under surface of the body may be observed a row of minute pores, a pair usually existing on each segment; these are the stigmata, or apertures for the admission of air to the respiratory organs, which consist of *tracheæ* or air-tubes resembling those of Insects. These tracheæ, however, do not so completely unite into a system, as in that class (§ 619); for those of the several segments have but little communication with each other.—The character of the other organs strongly resembles that of the similar parts in Insects, though not so highly developed. The alimentary canal runs straight, or nearly so, from one end of the body to the other; and possesses a few glandular appendages, in the form of a long tube very imperfectly developed. The circulation is carried on by the aid of a long *dorsal vessel*, which extends along nearly the whole length of the body. The nervous system presents a multiplication in its ganglionic centres, corresponding with the multiplication in the number, and

FIG. 507.—POLYDESMUS.

the similarity in the character, of the segments.—The Myriapoda cannot be said to undergo any proper metamorphosis, like that of Insects and some Crustacea; since the young one, at its emersion from the egg, possesses the form and most of the general characters of the parent; but there is a gradual increase, during the period of growth, not merely in the size of the body, but in the number of segments and legs; and in one division of the class (the Iulidæ), the young, when it first issues from the egg, is altogether unprovided with legs, these not making their appearance until after the first moult, although they are found beneath the outer skin when it is stripped off. A considerable number of moultings takes place before the animal acquires its adult characters; and this does not happen, in some species, until after the lapse of two years.

FIG. 508.—TRANSFORMATIONS OF IULUS; *a, b, c*, successive stages.

822. This Class is divided into two Orders, which differ considerably from each other in form and development.

I. CHILOPODA, consisting of the *Centipedes* and their allies; in which the body is flattened, and the legs well-developed, constituting the principal instruments of locomotion. They run with facility; and are carnivorous in their habits.

II. CHILOGNATHA, consisting of the *Iulus*, or *Millepede*, and its allies; in which the body is cylindrical, and the legs less developed. They move slowly; and feed upon decomposing organic matter.

ORDER I.—CHILOPODA.

823. This Order is the one, in which the greatest resemblance to Insects may be traced. It consists of the *Centipede* and other carnivorous Myriapods, possessing strong and active limbs, varying in number from fifteen to twenty-one pairs, by the aid of which they can run with considerable rapidity; and they are

able, owing to the flexibility of their long and jointed bodies, to wind their way with facility among the lurking-places of Insects, against which they carry on an unrelenting warfare. Of their

FIG. 509.—SCOLOPENDRA, OR CENTIPEDE.

carnivorous propensities, the structure of the mouth affords sufficient evidence. It is provided, not merely with a pair of horny jaws resembling those of Insects, but with a pair of strong sharp claws, formed by an enlargement of the second pair of legs, and perforated at the top with a minute aperture, through which a venomous fluid is probably instilled into the wounds made by them. Small insects seized in these claws are seen to die very speedily; and in warm countries the bite of the large species of Centipede is a source of great irritation to man,—being reputed to be more injurious than that of the Scorpion, although it is seldom fatal. The application of Ammonia (Hartshorn) is the most effectual remedy for the pain of the bite; and the internal employment of the same remedy seems the best antidote to the effects of the poison upon the constitution. The last pair of legs usually undergoes some modification in this Order; being directed backwards so as to form a kind of double tail; and not being used for walking, except when the animal is walking backwards. The European species of this Order seldom exceed three inches in length; but they are by no means uncommon, if sought for in the right situations. They frequent dark places, hiding themselves under stones, beneath the bark of trees, in the ground, and in the hollows of ripe fruit,—situations that are the resort of the Insects on which they feed. The tropical species not unfrequently attain

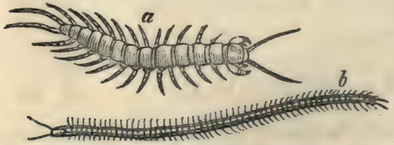


FIG. 510.—*a*, LITHOBIUS FORCIPATUS; *b*, GEOPHILUS LONGICORNIS.

a length of from twelve to fifteen inches; and it is stated by Ulloa, that they have been seen at Carthagena exceeding a yard in length and five inches in breadth, and that the bite of these is mortal. It is doubtful, however, whether this statement can be fully relied on.

ORDER II.—CHILOGNATHA.

824. This Order, consisting of animals having a general resemblance to the *Iulus* or common *Millepede*, is the one most nearly allied to the Annelida, not merely in external form, and in the imperfect development of the legs, but also in the structure of the internal organs. The body of the *Iulus* (of which one of the commonest species is known as the Gally-worm) is long and cylindrical; its number of segments is between forty and fifty; and many of these bear two pairs of almost thread-like legs, which arise close to the middle line, along the inferior surface of

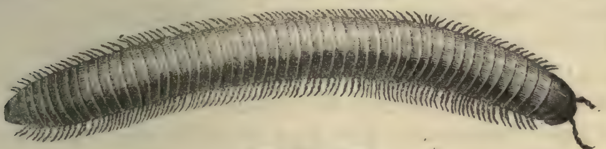


FIG. 511.—IULUS.

the body. These are scarcely large or strong enough to support its weight; so that the animal moves but slowly, and seems rather to glide or crawl, like a serpent or a worm, than to walk. When at rest, the body is rolled up in a spiral form; so that the feet, being concealed in the concavity of the spire, are protected from injury; whilst the firmness of the rings of the body enables them to resist considerable pressure.—The mouth of the *Iulidæ* strongly resembles that of the Larvæ of many Insects, being furnished with a pair of stout horny mandibles, with sharp toothed edges;

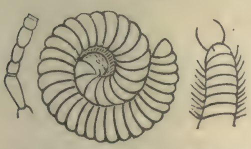


FIG. 512.—IULUS, with the body coiled up, and the front of the body unrolled, with the antennæ magnified.

and by means of these, they are enabled to divide with facility

the portions of decaying vegetable matter, on which they usually feed. These animals are very harmless to Man, not being possessed of any poisonous organs; and they may be regarded as positively benefiting him by the removal of substances whose decay would otherwise be noxious. The common Iulus of this country seldom much exceeds an inch in length; but there is a South American species, *Iulus maximus*, which attains the length of seven inches.—The *Polydesmus* (Fig. 507) corresponds with the Iulidæ in general structure and habits, but has the body remarkably flattened.—The *Glomeris* bears a strong resemblance to the Woodlice (§ 799), in its oval form, and its habit of rolling itself into a ball; it is also remarkable from its small number of segments, those of the body being only twelve, as in Insects. The under surface of the body, which is concave, has a row of small scales on each side, which has been compared to the lateral lobes of the Trilobites and some of the Isopod Crustacea. Altogether the resemblance of this animal to that group is very striking; the chief difference being in the nature of the respiratory organs.—The animals of this Order are remarkable for their power of emitting a disagreeable odour, when they are alarmed. This seems to result from a peculiar secretion, poured out from the stigmata or respiratory orifices; and it may be regarded as a means of defence, which replaces the poison apparatus of the Centipedes.

FIG. 513.—GLOMERIS MARGINATA.

CHAPTER XII.

OF THE CLASS OF CIRRHOPODA.

825. The *Barnacles* and their allies, composing this class, have so many characters in common with the Mollusca, that they have been generally regarded as belonging to that Sub-kingdom. The body and its appendages are themselves quite soft; and the skin has the loose spongy muscular character, which corresponds with the *mantle* of the Mollusks (§ 868). From its surface is secreted a shell, composed of several pieces, but not differing in general aspect from *multivalve* shells (§ 870) belonging to that division. Further, these shells are either themselves firmly united at their bases to rocks or solid masses, or they are attached by a long peduncle or foot-stalk; so that the conditions in which the animals exist, closely resemble those to which we observe the Mollusca peculiarly adapted.

826. On the other hand, when we examine the animal itself, we find that it is perfectly *symmetrical* in form; a character but rarely observable amongst Mollusks that are inclosed in shells of similar nature (§ 864). The body is prolonged, and exhibits an imperfect division into segments; and from each of these arises a pair of appendages on each side, which possess somewhat of a jointed structure. These *cirrhi*, or tendril-like organs, are long tapering arms, fringed with *cilia*, or little hair-like filaments, by

FIG. 514.—SHELL OF THE BARNACLE.

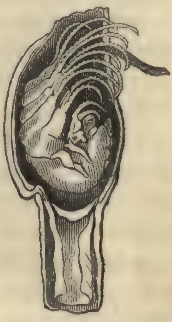


FIG. 515.—BODY OF THE BARNACLE.

the continual vibration of which, currents are produced in the surrounding water, that serve to bring food to the animal, and a fresh supply of fluid for the aeration of the blood by means of the gills, which are situated at the base of these appendages. In this conformation, there is an evident analogy with many Crustacea. Further, the mouth is furnished with *lateral* jaws, which no Mollusca possess; and the Nervous System consists of a double cord, with a pair of ganglia in each segment of the body, precisely as in the Articulata in general. The most interesting proof, however, that the Cirrhopoda belong to this division, is derived from the history of their development. On their liberation from the egg, they present a form much more analogous to that of some of the Entomostracous Crustacea, than to that of the adult animal, which they only acquire after a series of metamorphoses.

827. The young of the *Balanus* (§ 830) is inclosed in a bivalve shell, of which the valves are united by a hinge along the back, and open along the lower margin, for the protrusion of a large and strong anterior pair of prehensile limbs, provided with an adhesive sucker and hooks, and of six pairs of posterior legs, adapted for swimming. The form of the animal thus bears a strong resemblance to that of the *Daphnia* (§ 804); and its movements, too, are similar, consisting of a succession of jerks. A pair of compound eyes, supported on a peduncle, is seen on the anterior and lateral part of the body. Nearly all these organs are thrown off together; and the animal assumes an entirely different form and condition. It first attaches itself to a neighbouring surface by a layer of calcareous matter, which is subsequently to become the base of its new shell; the valves which surround its body are gradually developed on its envelope or mantle; the new ciliated arms begin to grow within; and the eyes disappear, the animal being henceforth destitute of the visual sense.—The form of the young *Lepas* is different, having more resemblance to that of the Cyclops (Fig. 496). The body is not inclosed in a bivalve shell, but its back is covered by an expanded shield, like that of Argulus (Fig. 498); it has a single eye, not stalked; and three pairs of members, of which the anterior is

simple, whilst the two posterior are bifid.—Hence, if their early state be alone considered, the Cirrhopods might be regarded as an aberrant order of Crustacea; but the complete change of form which they exhibit in their passage towards the adult state, involving the development of so many new parts, to which we find nothing analogous in the class of Crustacea, seems to remove them to a greater distance than even the aberrant Lerneida (§ 815).

828. The Class is divided into two principal groups, differing in many of their characters, though agreeing in those which have been hitherto described.

I. Pedunculata, or Lepadidæ. This Order, including the *Lepas* or *Barnacle* and its allies, consists of those Cirrhopods which are attached by a long fleshy peduncle or foot-stalk; their form is flattened at the sides; and the opening through which the cirrhi are protruded is along one edge. The mantle is sometimes cartilaginous; but in general it is covered by five calcareous pieces, of which the two principal ones resemble the valves of a Mussel or other Bivalve shell.

II. Sessilia, or Balanidæ. In this Order are associated those which attach themselves at once by their basis, like the *Balanus*, or Acorn-shell, so common on our rocky shores. In these, also, the shell is composed of several valves; but these are united into a cylindrical or somewhat conical tube, which is attached at one end, and open at the other to give passage to the arms, &c.

Order I.—PEDUNCULATA.

829. Of the common *Barnacle*, and its allies, which together make up this Order, some species are common in nearly all seas. Most of them fix themselves to wood in preference to anything else; so that a piece of timber, which has been for sometime floating in the ocean, is almost sure to be partly covered by them, and ships' bottoms, if not protected by copper, are rendered so foul, as greatly to impede their rate of sailing. This will be

easily understood, when it is borne in mind how greatly the friction will be increased, when the water, instead of being ploughed by a smooth surface, is held (so to speak) by excrescences, such as those represented in Fig. 516. The commonest species, *Pentalasmis anatifera*, is the one respecting which so many absurd stories were formerly told (Vol. I. p. 16). The peduncle sometimes grows to the length of two or three feet; and it possesses a considerable degree of contractility, enabling the animal, by its means, to change its place, in some degree, by the shortening, extension, or bending, of the footstalk. A large log of timber covered with these animals, twisting and diverging in all directions, and so close as to hide the surface of the log, is a curious sight,—looking like an enormous collection of Serpents.

FIG. 516.—Group of BARNACLES, attached to a ship's bottom.

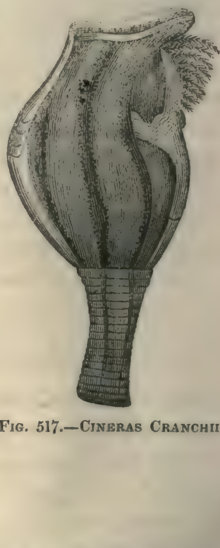


FIG. 517.—CINERAS CRANCHII.

In the *Cineras*, the mantle has somewhat of a cartilaginous tex-

ture; and the valves do not cover the whole surface. In the *Otion*, there are only two small valves, with the rudiments of three others.

ORDER II.—SESSILIA.

830. The shell of the *Balanus*, commonly known as the "Acorn-shell," and met with almost everywhere on our shores, is formed on a very different plan. It consists of six principal valves, of a triangular shape,—the base of each triangle being at the bottom, and the apex or point at the top. Within these, however, is another set of six smaller triangular valves, arranged in just the opposite direction, so as to fill up the space between the preceding, and to give to the whole shell somewhat the form of a cone with the top cut off. The aperture of the shell is closed by an operculum, or lid, composed of two or four pieces; this the animal can apply to the orifice, in such a manner as to close it completely, when its body is entirely drawn within the shell. The growth of this shelly box is provided for by additions to the edges of the several plates of which it is composed; these additions increasing the size of the whole, without altering its form. Between the internal and external layers of each valve, there is a regular *cancellated*, or minutely-chambered structure, like that of Bone (ANIM. PHYSIOL. § 47); and this appears to be filled, as in *it*, with a sort of marrow. No structure resembling this has been found in any Mollusca. It is especially developed in the *Coronula*, a genus allied to the Balanus, which is only found attached to the back of Whales and Turtles.

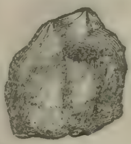


FIG. 518.—BALANUS.

CHAPTER XIII.

OF THE VERMIFORM CLASSES.

831. We are now arrived at the lower division of the Articulated Sub-kingdom, in which there is an absence of articulated members, and a general inferiority in the structure of the animals composing it; so that, as we descend, we lose one after another of those characters, by which this group is distinguished. Nevertheless, the *lateral symmetry* (§ 47) of the body is almost uniformly preserved; and it is only in the very lowest that we meet with any approach to the *circular* arrangement of the parts of the body, which is characteristic of the Radiata. The Nervous System cannot be traced in the simplest animals of this division; but wherever it can be detected, it presents the same essential characters as in the higher classes,—consisting of a double cord running along the ventral surface from one extremity of the body to the other, and studded with ganglia at intervals. These ganglia are smaller, in proportion as they are more numerous; and their size diminishes, too, with the diminution of the locomotive powers of the animal. The *cephalic* ganglia, or those which are placed at the anterior extremity of the body, above the œsophagus, are usually larger than the rest; especially when they are connected with organs of special sense, such as eyes and antennæ. But as we descend through this series, we find the eyes disappearing, and then the antennæ; so that the *head* is only marked by its being the situation of the mouth; and the cephalic ganglia are then scarcely to be distinguished from the rest.

832. The body of these animals is generally long, slender, and more or less cylindrical; it is frequently divided into distinct segments; but these are only marked externally by a folding or wrinkling of the integuments; and there does not

exist any proper tegumentary skeleton or hard envelope, as in most of the higher classes of Articulata. In the lowest mem-

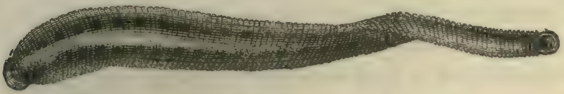


FIG. 519.—LEECH.

bers of the class, indeed, we cannot even trace an integument distinct from the contained tissues; all being alike soft, and sometimes almost jelly-like. Even here, however, the division into segments is most distinctly marked, by the repetition, in each segment, of nearly all the organs of the body; so that the animal is much more capable of sustaining severe injuries, than is the case in the higher classes; and it has also greater power of repairing them, new segments being developed to replace those which had been lost. The greater number of the Vermiform or Worm-like Articulata are aquatic in their habits, living either in water or in moist situations; and as a general rule, their respiration is performed either by gills, or by the general surface of the body. They have usually a distinct circulating apparatus; which serves not only to convey the nutritious fluid through the several tissues, to whose growth it is to contribute, but also to carry it to the organs in which it is to undergo aeration. This apparatus consists, as in Insects, of a *dorsal vessel*, running along the greater part of the body, and contracting from behind forwards, so as to expel the blood through the branches which proceed from its anterior extremity; the fluid then flows backwards through the body, affording nutriment to its several parts in its course; and it is then made to flow over the walls of the alimentary canal, so as to take up from its cavity any new materials, which may have been prepared for it. The provisions for carrying it through the respiratory organs vary greatly, in proportion to the variety in the arrangement of the respiratory organs themselves, which we shall see to be great, as it is in the Mollusca: but there is not unfrequently a distinct contractile cavity, or respiratory heart (ANIM. PHYSIOL. § 281), for propelling the blood through every pair of gills, as in the

Crustacea (§ 777). In the lowest Articulata, however, no dorsal vessel, or impelling organ of any kind, can be discovered; and the circulating system consists merely of a network of capillary vessels, occasionally merging into larger trunks; the blood being propelled through it by the continual movements of the body itself, which act upon it in somewhat the same manner that our own changes in position do upon our venous circulation (ANIM. PHYSIOL. § 279).

833. This group may be regarded as especially represented by the class ANNELIDA; which contains, with the Leech and Earthworm, a great number of marine animals less generally known. In the ENTOZOA, we find the characters of the Articulated series in their lowest state of development. And in the ROTIFERA, we meet with peculiarities of form so great, that the affinity of the minute animals it contains to the preceding classes, is by no means apparent without a careful examination.

CLASS OF ANNELIDA.

834. The Annelida may be characterised as possessing an elongated body, marked by transverse lines that divide it into numerous segments: and usually furnished with a series of locomotive appendages in the form of bristles, sometimes implanted on fleshy tubercles; but not with articulated members. They have a complete apparatus for circulation and respiration; and

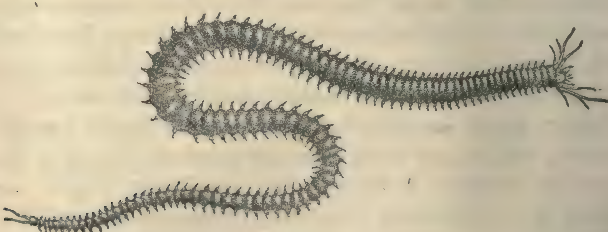


FIG. 520.—NEREIS.

the ventral chain of nervous ganglia may always be distinguished. —Of the appendages, which often combine the functions of loco-

motion and respiration, there are frequently two pairs in each segment; one belonging to its upper or *dorsal* portion, and the other to its lower or *ventral* (Fig. 594): but in other instances the two appendages on the same side are united (Fig. 527). We usually then find, in the marine Annelida, that

Fig. 524.

FIG. 521.—GILL-TUFT OF EUNICE.

the ventral portion is chiefly devoted to locomotion; and the dorsal to respiration. Thus, in the *Eunice*, we find, at the under part, a fleshy tubercle (t), furnished with a tuft of bristles, and below it a rudimentary *cirrhus*, or tendril-like organ (i); whilst the upper part of the appendage is formed by a branchial tuft (b), and by a long slender cirrhus (c). This last sometimes exhibits a trace of articulation, as in the *Syllis* (Fig. 522, a). In other cases, however, these appen-

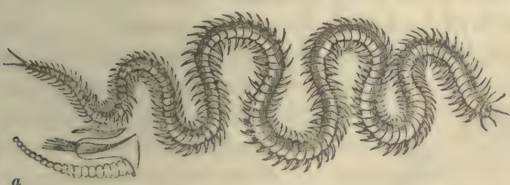


FIG. 522.—SYLLIS MONILARIS, with one of its locomotive organs and setigerous appendage attached thereto.

dages are only represented by a few short stiff hairs, as in the *Earthworm;* and in other instances, as the *Leech*, there is no trace of any members or appendages to the body. The bristly tufts of the Nereidans and their allies are useful to them in various ways; they serve them in part as instruments of attack and defence, the bristles being usually sharp, and sometimes barbed at their extremities, so as to attach themselves with force to soft substances; they assist, also, in their movements over solid surfaces, taking hold, as it were, of the rock on which the animal is crawling, so that the hinder part of the body is prevented from slipping back, when the anterior part is pushed forwards; and they also aid in its movements through the

water, serving in some degree as oars by which it is propelled. In some instances, indeed, we find the tufts replaced by flattened plates, which are specially adapted for this last purpose. Where there are no locomotive appendages, the extremities of the body are usually furnished with suckers, which give important assistance in locomotion,—as in the well-known Leech. But in one tribe of this class, the animal, in its adult form at least, enjoys very little power of locomotion, being confined within a shell, which it constructs for itself, and which is attached to some solid support.

835. The first segment, which constitutes the head, is usually provided with one or more pairs of imperfectly-formed eyes; and also with several appendages analogous to the *cirrhi* of the other segments, which are considered as antennæ or tentacular cirrhi. The mouth, which is situated on the lower side of the head, is constructed on a very different plan in the several divisions of the class: being sometimes furnished with one, two, or three pairs of hard horny jaws, with toothed or pointed edges; sometimes having a sort of trunk, which can be pushed out or drawn in (Fig. 523), and which bears a pair of small tooth-like jaws at its extremity; and sometimes being situated in the centre of a flattened sucker, and armed with an apparatus of little saws, as in the Leech (Fig. 532). The alimentary canal is usually simple in its form, passing in a straight line from one end of the body to the other; and not exhibiting any distinction of stomach or intestine. It is often furnished with a number of little saccular appendages, placed along the greater part of its length; these are probably secreting organs, as we do not find any others which can be regarded as having that character. Many of the Annelida are remarkable for the red colour of their blood; this colour is not given, however, by red corpuscles, but exists in the *liquor sanguinis* (ANIM. PHYSIOL. § 229). Sometimes, however, the blood has rather a

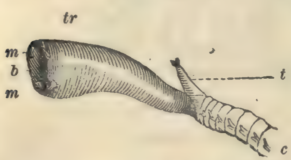


FIG. 523.—HEAD AND TRUNK OF GLYCERIS; *c*, anterior portion of the body; *t*, head; *tr*, trunk; *b*, opening of the mouth; *m*, *m*, jaws.

greenish tint; and in many instances it is colourless, as in the Annelida in general.

836. Little is known of the history of the development of the Annelida; but there appears to be considerable variation in the amount of change they undergo after coming forth from the egg. The Nereidans, in their early stage, seem to bear a very close resemblance to Infusory Animalcules; for they are described as consisting of a simple disc, surrounded with two rows of vibratile *cilia*, which serve for locomotion, and for the acquirement of food. The mouth, which is situated near the edge of the disc, leads to a short, straight alimentary tube, which terminates in a sort of cone projecting from its lower side. In a short time this conical projection begins to increase in length, and to show a division into segments; and by a gradual increase in the number of these, the body is at last formed. At the same time, the formation of the head takes place by a gradually-increasing projection of the other surface of the disc. Whilst the head and body are being developed, this first-formed disc remains for a time as a sort of appendage on each side of the head; but it finally disappears. In the Leech and Earth-Worm, on the other hand, the development of the young seems to be nearly complete, by the time that they leave the egg.—We find in this group the first appearance of that *gemmiparous* mode of reproduction, which is especially characteristic of Zoophytes (ANIM. PHYSIOL. §§ 723-730). The accompanying figure represents the mode of propagation of the

FIG. 524.—NEREIS PROLIFERA.

Nereis prolifera; in which a young one is formed from the hinder part of the body of the parent, its head being produced by a conversion of one of the segments of its body; and this is gra-

dually detached by a narrowing of the preceding joint. Previously to its separation, however, the young one often forms another bud from its own hinder part, in a similar manner; and even *three* generations have been seen thus united.—From observations recently made on another Marine Worm, in which a similar occurrence takes place, it would appear that the *buds* thus detached are, like the flowers of Plants, destined to Reproduction only; for whilst the parent continues to grow, to obtain its food, and to develope new buds from its hinder portion, these buds do not seem to grow into new individuals like their parents, —but, although possessing a head, mouth, and alimentary canal, they do not take in nourishment, their functions being restricted to the laying of eggs, from which new Nereids spring.—Something analogous to this is met with among the Entozoa; the posterior segments, containing the ova, being detached from the rest of the body, and thrown off altogether.

837. This Class is subdivided into Orders, according to the differences in general conformation and habits exhibited by the tribes which compose it; and especially by the character and distribution of the respiratory organs. The first Order, Dorsibranchiata, includes those which have the branchial appendages or gill-tufts disposed regularly along the body, sometimes extending along its entire length, and sometimes restricted to the segments about the middle. This Order has been also denominated *Errantia*, from the active habits of the animals composing it.—II. In the next, Tubicola, we find worm-like animals inhabiting fixed and permanent residences, like the testaceous Mollusca. The disposition of the gill-tufts around the head, and the absence of them along the body, is the principal character which distinguishes the animals themselves from those of the first Order.—III. In the third Order, Terricola, the body is destitute of all external appendages, except some minute and almost imperceptible bristles; for the respiratory organs are here developed internally, the animal being usually formed to crawl upon the ground, instead of swimming through the water.—IV. And in the last, Suctoria, the body is destitute even of these bristles, but is furnished with a sucker at each extremity.

ORDER I.—DORSIBRANCHIATA.

838. Of the foregoing Orders, the Dorsibranchiata appear, on the whole, to possess the most complete structure, as well as the most varied faculties; and they also exhibit the forms most characteristic of the class. The head is almost always quite distinct from the trunk, and is furnished with one or two pairs of minute eyes, which are seen as black or reddish specks upon its upper side; and it is also provided with several pairs of appendages (Fig. 525), as well as with complex instruments of mastication. These Marine Worms do not attain any considerable dimensions upon our coasts, rarely exceeding a few inches in length; but in tropical climates, species are to be met with of comparatively gigantic proportions, having their bodies composed of 400 or 500 segments, and occasionally measuring four feet from one end to the other. They generally crawl with facility, and swim rapidly; their chief habitations are among rocks and masses of shells; but some of them bury themselves in the sand, forming a sort of burrow, lined by mucus secreted from their bodies, which they quit in search of their prey. They are all carnivorous, and live on various small marine animals.

FIG. 525.—HEAD AND ANTERIOR SEGMENTS OF NEREIS.

839. The NEREIDÆ, commonly known as *Sea-Centipedes* (Fig. 520), may be regarded as characteristic examples of this group. They are distinguished by having the gills in the form of leaf-like appendages or laminæ, which are traversed by a network of vessels; and every segment has, on either side, two tubercles, two cirrhi, and two tufts of bristles. They have none of that venomous power, which their name might be supposed to indicate; but they are extremely voracious, and thread the most intricate passages and crevices among rocks and stones, in pursuit of their prey. In their turn, they are devoured by Fishes.—The *Eunice* is nearly allied to the Nereidæ; but has gills composed of filamentous tufts (Fig. 521, *b*), instead of leaf-

like plates.—The *Eunice gigantea* of West Indian seas is the largest Annelide known; sometimes measuring four feet in length. There are smaller species upon our own coasts.—In the *Amphinome*, the gills have the form of branching or arborescent tufts; and these are disposed along the whole of the body. They are frequently coloured very brilliantly.—The allied genus *Euphrosine* has these branchial tufts very much developed; and the body, instead of being long and narrow, has a broad and oval form.—The *Arenicola*, or Lob-worm, is an animal well known on our coasts; being sought for by Fishermen, who use it as a bait. Its gills, like those of the preceding genera, have an arborescent form; but they are disposed on the middle part only of the body. As its name imports, it lives in the sand, in which it burrows to the depth of twelve or eighteen inches: its situation may be known by a little *coil* of sand, which is seen on the spot beneath which it is to be found. The Arenicola is one of the Annelidans most distinguished by the red colour of its circulating fluid; and this colour is peculiarly seen in the branchial tufts, which have a beautiful crimson hue during the life of the animal.—The *Aphrodita* is an animal well known on our coasts under the name of "Sea Mouse;" probably on account of the large quantity of silky hairs with which it is covered. These hairs are of a very brilliant metallic lustre; and their colours vary with the play of the light; so that this animal is scarcely surpassed by any, in beauty of colouring. The back is furnished with two rows of large membranous scales, which somewhat resemble the elytra of Insects; these inclose the gills; but they are themselves concealed by the hairy covering just mentioned. The form of the body much resembles that of the Euphrosine (Fig. 526). A large number of Aphroditæ are not unfrequently thrown up on our coasts after a gale of wind. In many species,

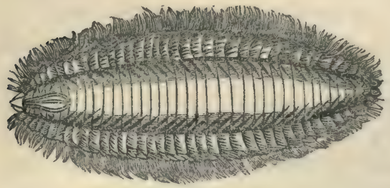


FIG. 526.—EUPHROSINE LAUREATA.

the lateral setæ or bristles exhibit a beautiful structure, which admirably fit them for weapons of defence, being barbed on each side at their tips; and each of these barbed setæ is inclosed in a smooth horny sheath, composed of two blades.—Lastly, we may mention a very curious genus, *Peripatus*, which is probably to be placed in this order, although it is a resident on land. In some respects it bears a resemblance to the Iulidæ (§ 824), having legs adapted for walking, which present some appearance of articulation or jointing; but in the softness of its body, and in the termination of the legs in tufts of bristles, it evidently corresponds with the Nereidans.

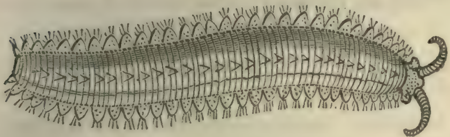


FIG. 527.—PERIPATUS IULIFORMIS.

ORDER II.—TUBICOLÆ.

840. The animals of this order never attain to the same dimensions with the preceding; and more is known of the casings which they form, than of the structure of the animals themselves. One of the commonest of these is the shelly tube exuded by the *Serpula;* which is formed of calcareous matter, resembling that of the shells of Mollusca, and apparently secreted from the surface of the body in a similar manner. In fact, it is often scarcely possible to distinguish between the shell of a Serpula and that of a Vermetus (Fig. 583). The tubes of the Serpulæ (Fig. 528) are generally found clustering in masses, attached to the surface of stones, shells, or other bodies, which have been immersed for any length of time in the sea; they are usually more or less contorted in form, varying in this respect according to the position in which they grow; but they are always closed at one end, which tapers to a point, the wide end being open to give exit to the head and mouth of the inhabitant. The animal which forms this shell, and resides in it, has its branchial filaments or gill-tufts all assembled round the head; where they form a pair of

most elegant fan-like appendages, which usually possess very brilliant colours. At the base of each series, there is a fleshy filament; and one of these, on the right or left side indifferently, is prolonged and dilated at its extremity into a flat disc, which fits to the mouth of the shell, and serves to close it when the animal is withdrawn into the tube. The body of the animal is composed of a great number of segments; but these are for the most part unprovided with any appendages. The anterior segments, however, which are much thicker than the rest, are furnished on each side with bundles of stiff bristles. The largest species of this, as of the preceding groups, are found in tropical regions, where they usually form their habitations in the midst of Corals, and lengthen their tubes as the Coral is built up around them; their length is sometimes as much as three feet; and their expanded gill-tufts are of extremely vivid colours, strongly resembling the most brilliant Carnations in general aspect. These are usually extended beyond the mouth of the shell, in order to obtain the full influence of the water, for the aeration of the circulating fluid; but if they be touched, they are immediately drawn in, and the mouth of the tube is closed by the disc just mentioned. Numerous smaller species are found on our own coasts; and some of these are remarkable for the brilliant hues of their expanded gills.—A minute white spiral shell may be frequently seen upon the flat fronds of seaweeds; this is the *Spirorbis*, the animal of which is nearly allied to that of the Serpula. The food of these Annelids probably consists of Animalcules and small marine animals; together, perhaps, with particles of dead animal matter, which are brought towards the mouth, by the currents created by the *cilia* on the branchial tufts: their masticating apparatus is much less complete than that of the Dorsibranchiata.

FIG. 528.—GROUP OF SERPULÆ.

841. Besides the Serpulæ, we have to mention several other

animals of this group, which do not form their tubes by a calcareous exudation from their own bodies, but by cementing together particles of shell, sand, small pebbles, &c., by means of a glutinous secretion. We may first notice the *Sabella*, which seems to have some power of exuding calcareous matter; and forms its shell partly of this material, and partly of granules of clay or fine mud. In the arrangement of its gill-tufts, it bears a strong resemblance to the Serpula.

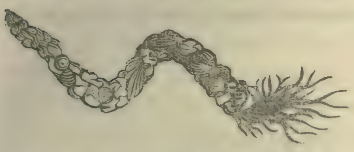


FIG. 529.—TEREBELLA MEDUSA, in its tube.

The *Terebella* forms its tube entirely by the agglutination of grains of sand, pieces of shell, &c.; and some species live in groups, so that their clustering-together forms solid masses, which may go on increasing to a considerable size. The gills are here smaller, and are placed behind the head, having the form of small arborescent tufts; and the head is furnished with numerous tentacula, which are capable of being greatly extended. These probably assist the gills in the aeration of the blood, as they present a large surface to the water; but their chief use appears to be the prehension of food. The shelly tubes usually have little branches near their summit, through which the gills and the tentacula pass out. The Tubicolæ of the genus *Amphitrite* are distinguished by their large golden-coloured setæ, disposed in a comb-like series, or in a crown, or in one or several ranges on the front of the head; these probably serve them for defence, and may give assistance in locomotion. Many of these animals, belonging to the subgenus *Pectinaria*, are less confined to one spot than the preceding; their tubes, which are composed of fine grains of sand cemented together with great regularity, are simple cones open at both ends, and not attached;

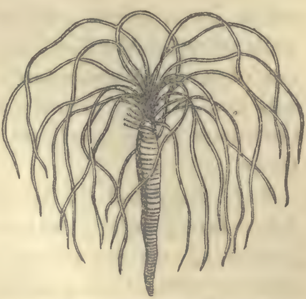


FIG. 530.—TEREBELLA VARIABILIS.

and they carry these about with them, when roaming in search of food. It is perhaps in consequence of their locomotive powers, which give them a greater facility of *selection*, that they construct their shelly tubes with so much more regularity than other Annelidans. These tubes, usually about two inches long, may be frequently picked up on our shores. Some of this group, however, are fixed like the other Tubicolæ, and form their tubes less regularly. Their bodies are doubled up, as it were, within these envelopes; so that the intestine terminates in a tube which is curved back over the head.

ORDER III.—TERRICOLÆ.

842. The Annelidæ of this Order have a cylindrical body, tapering to a point at its extremities, and furnished only with several rows of bristles; these are frequently invisible to the naked eye, but may be distinguished by the resistance they make when the finger is passed along the body from behind forwards,—their points being directed backwards, in order to give the animal a firm hold of the earth through which it is boring. The head of these animals is not distinct from the body; and they have neither eyes, antennæ, mandibles, cirrhi, nor external gills. Their bodies, however, are distinctly divided into segments; and these are marked by minute spots on each side (Fig. 531, *a*), which are apertures leading to small respiratory sacs, on the walls of which the blood is submitted for aeration to the influence of the air or water received into them. This Order includes only two principal groups; the *Earth-Worms* and the *Naids*,—the former being inhabitants of the land, and the latter of the water.

843. The *Earth-Worms*, which nearly all belong to the genus *Lumbricus*, generally live beneath the surface of the ground, either perforating the dry soil, or burying themselves in mud, where many of them lead a semi-aquatic life. When the Worm is boring, it insinuates its pointed head between the particles of the earth amongst which it penetrates like a wedge; and in this position, the anterior part of the body is fixed by the spines or

bristles, of which there are four pairs on each segment (Fig. 531, *b*). The hinder parts are then drawn forwards by a shortening of the body,—a movement which the spines do not oppose; this swells out the anterior segments, and forcibly dilates the passage into which the head had been already thrust. The spines upon the hinder rings then take a firm hold upon the walls of the hole into which they have been drawn; and this part of the body being now made a fixed point, the head is again forced forwards by the powerful contraction of another set of muscles; and by a repetition of this process, the animal easily makes its way through substances, which it would at first have seemed impossible for it to penetrate. The muscles, by which this action is performed, are disposed in two series; the arrangement of which is very characteristic of the Articulata in general, though it is less obvious in the higher classes, whose locomotion is chiefly effected by the action of the extremities. The muscles of one series are *longitudinal* in their direction, passing from segment to segment, and serving by their contraction to draw the segments together, in such a manner as to shorten the body, at the same time increasing its diameter. The muscles of the other series have a contrary direction, forming rings round the body, and tending by their contraction to diminish its diameter, and consequently to increase its length.

844. The burrowing of Earth-worms is a process exceedingly useful to the Gardener and Agriculturist; and these animals are far more beneficial to Man in this way, than they are injurious by devouring the vegetables set in the soil. They give a kind of under-tillage to the land, performing the same below ground that the spade does above for the garden, and the plough for arable land; and loosening the earth, so as to render it permeable to air and water. It has been lately shown, that they will even add to the depth of soil; covering barren tracts with a layer of productive mould. Thus, in fields which have been overspread with lime, burnt marl, or cinders, these substances are in time covered with finely-divided soil, well adapted to the support of vegetation. That this result,—which is commonly attributed by the farmers to the "working-down" of the materials in question,—is really due to the action of the Earth-

worms, appears from the fact that, in the soil thus formed, large numbers of "worm-casts" may be distinguished. These are produced by the digestive process of the Worms; which take into their intestinal canal a large quantity of the soil through which they burrow, extract from it the greater part of the decaying vegetable matter it may contain, and reject the rest in a finely-divided state. In this manner, a field, manured with marl, has been covered, in the course of 80 years, with a bed of earth averaging thirteen inches in thickness.

845. It is commonly supposed that the Earth-Worm may be multiplied by the division of its body into two pieces, of which each will continue to live. This does not, however, appear to be the case with regard to the common species. If it be divided across the middle, when in motion, each part will continue to move for a time; but only the piece which bears the head will be found alive after a few hours. This forms a new tail; and soon shows little sign of injury. But if the division be made near the head, the body will remain alive, and will renew the head; and the head, with its few attached segments, will die.—There appear, however, to be some species, in which this reproductive power is sufficiently great to produce a new head and body from even a small portion of the original; so that above twenty individuals have been produced in this manner, by the division of a single one into as many parts. This power is even greater in the Naids; which also produce buds, that separate from the parent by spontaneous division, as in the *Nereis prolifera* (§ 836).—The propagation of the Earth-worms presents some other very remarkable peculiarities. The

FIG. 531.—LUMBRICUS TERRESTRIS, OR EARTH-WORM; *b*, anterior segments magnified, showing the bristles directed backwards; *c*, egg enclosing two young; *d*, escape of young worm from the egg.

ova, when they have been fertilised, quit the ovarium, not by oviducts or passages leading outwards, but by finding their way into the loose tissue of the body, beneath the muscular layer; through this they are propelled by a series of strong undulations, until they reach a sort of receptacle, in which they undergo the first part of their development, and within which, in some species, the eggs are hatched, so that the young come forth alive. The eggs are provided with a curious valve-like structure at the end through which the young worm emerges; and it is remarkable that, in a great number of instances, two embryos may be observed in a single egg.

846. The genus *Nais* is nearly allied to the Lumbricus; but the worms which it includes are aquatic in their habits, living in holes which they perforate in mud at the bottom of water. Some of them have small black points upon their heads, which have been regarded as eyes.

Order IV.—SUCTORIA.

847. This Order contains the common Leech and its allies, which are all animals of aquatic habits, but not all agreeing in its blood-seeking propensities. The group derives its name, as already stated, from the suckers which terminate the two extremities of the body, and which constitute its chief means of locomotion; for having fixed its anterior extremity, the animal draws the posterior one close up to it, by bending its body,—and then, fixing the latter, re-advances the first, by straightening and extending the body. In this manner the Leech can advance much more rapidly over solid surfaces, than the Earth-Worm can by its crawling movement; and it can also swim with facility.

848. The *Leech*, in its general structure, bears a considerable resemblance to the Earth-Worm; but differs as to the conformation of its mouth and digestive apparatus, which are in accordance with its suctorial habits. Its mouth is situated in the middle of the cavity of the anterior sucker; and three little

cartilaginous bodies, usually called *teeth*, but more properly *jaws*, are seen to be disposed around it, in such a manner that the

FIG. 532.—HIRUDO OFFICINALIS.

three edges form three radii of a circle. Each of these has two rows of minute teeth at its edge, so that it resembles a small semi-circular saw. It is imbedded at its base in a bed of muscle, by the action of which it is worked, in such a manner as to cut into the skin,—a sawing movement being given to each piece separately. It is in this manner that the tri-radiate form of the leech-bite is occasioned; each ray being a separate little saw. The lacerated character of the wound is very favourable to the flow of blood; which is further promoted by the vacuum created by the action of the sucker. The alimentary canal is straight; but is furnished, at its posterior portion, with a large number of little sacs, or cæca, opening from it. The operation of digestion is extremely slow, notwithstanding the rapid and excessive manner in which the Leech fills its stomach; a single meal of blood will suffice for many months; nay, more than a year will sometimes elapse, before the blood has passed through the alimentary canal in the ordinary manner, during all which period so much of the blood as remains undigested in the stomach continues in a fluid state.—Leeches are furnished with eight or ten simple eyes, which may be detected by the aid of a magnifying-glass, as a semicircular row of black points, situated above the mouth upon the sucking surface of the oral disc; this position is evidently calculated to render these organs of use in the discovery of food. Each of these visual specks would seem to be merely an expansion of the extremity of a nerve, derived from the cephalic ganglia, spread out beneath a kind of cornea formed by the delicate and transparent cuticle, and having behind it a layer of black pigment; nothing like a crystalline lens can be discovered; so that the vision of these animals must

be extremely imperfect.—The greater number of the Leech tribe are inhabitants of fresh water; some, however, are only found in the sea; others live in moist situations near stagnant water, pursuing Earth-Worms, &c.; and there is one small species, entirely terrestrial, which inhabits the woods of Ceylon, and attacks men and horses that are passing through them, in such a manner as to become, from its great voracity, one of the most troublesome pests of that fine island.

849. As connecting this order with the next, we may here place the genus *Gordius*, a long thread-like Worm, scarcely exhibiting any marks of articulation on its body, and having no distinct respiratory organs. Its various species inhabit fresh and stagnant waters, mud, and marshy grounds; and are commonly found with their long bodies coiled up into complex knots,—whence the name of the genus. The mouth is a simple pore at the anterior extremity of the body, which is conical; the tail, on the other hand, which has been mistaken for the mouth, is bifid (Fig. 533, *a*).

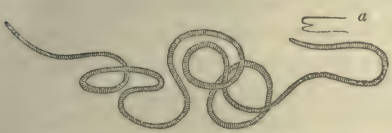


FIG. 533.—GORDIUS AQUATICUS.

CLASS OF ENTOZOA.

850. This class derives its name from the peculiar mode of existence of the animals composing it; most of them being inhabitants, during their whole lives, of the bodies of other animals, generally of higher organisation, from the juices of which they derive their nourishment. Many of these possess a distinct worm-like form (Fig. 534); the body being much prolonged and exhibiting a division into segments, and the mouth being situated at one extremity. These, therefore, evidently belong to the Articulated series. There are others, however, which, in their general form, the simplicity of their organisation, and the circular arrangment of the organs about the mouth, seem to approximate more to the Radiata (Fig. 536).

851. There is a very interesting group, consisting of the genus *Planaria* and its allies; which is placed in this class on account of its general conformity with it in *structure;* although not agreeing as to the *residence* of the animals composing it,—these not being inhabitants of the bodies of other animals, but swimming freely in waters of the ocean, as well as in streams and ponds, and crawling upon their banks, or upon floating substances. The body is flat, and three or four times as long as it is broad. Within its soft tissue are channelled out, not only a complex digestive cavity, but also a system of vessels which absorb fluid from its walls, and convey it through the system. The stomach opens, not by a mouth at one end, but by a sort of sucker projecting from the middle of the body; and through this the Planaria imbibes the juices of various aquatic animals which it attacks; mastering even the most active little worms (such as the Nais) by twisting its body round them.—The most curious part of the economy of these animals consists in their power of reproducing parts that have been lost, and of repairing injuries; which seems to be almost as great as that of the Hydra among Polypes. They may be divided into three parts; of which the first shall contain the two minute spots which are believed to be eyes; the middle one the sucker; and the posterior one the reproductive apparatus; and in a short time, each part will develope itself into a new individual, perfect in all its parts. It may be partially split longitudinally from either extremity, so that two heads, or two tails, or both in combination, may be formed, all uniting at the middle point, but each being complete in itself.

852. The proper ENTOZOA do not present many points of *general* interest; although their peculiar relations to Man, and the numerous varieties of structure which they present, render them objects of much scientific interest to the professed Naturalist and Physiologist. For obvious reasons we shall here content ourselves with a very general sketch of the group.—It may be divided into two primary Sections, according to the degree of development of the principal organs. In the first and highest of these, the STERELMINTHA, there is a distinct intestinal tube

with an orifice at each end, floating freely in an abdominal cavity, as in higher animals; and there are also traces of a nervous and muscular system, more or less developed. This division evidently approximates to the Annelida.—In the lower division, CŒLELMINTHA, there is no distinct alimentary canal; the cavities for the reception of food, as well as those for other purposes, being, as it were, channelled out of the soft, almost homogeneous, tissues of the body. Some of these, too, preserve the Worm-like form; but in others this can scarcely be traced.

853. SECTION I. STERELMINTHA. A characteristic example of this group, possessing a very distinct nervous system, is presented by the *Linguatula tænioides* (Fig. 534); a Worm which infests the frontal sinuses of the horse and dog.—The *Ascaris lumbricoides*, or Round Worm of the human intestines, also belongs to this group. It infests not only man, but many of the lower animals; and sometimes occasions severe disease, and even death. It derives its second or specific name from its resemblance to the Earthworm. The short active Thread-worms, sometimes infesting the lower part of the intestine, and giving rise to great irritation, but not to such severe consequences as the preceding, constitute another species of the same genus.—We may also notice the *Filaria*, or Guinea-worm, which burrows in the flesh of man and other animals in warm climates; if undisturbed, it will often continue its operations for a considerable time without much uneasiness; but if disturbed, it sometimes occasions the most excruciating pain. When it shows itself externally, it must be extracted very slowly and carefully, for fear of breaking it; since, if this should occur, the part remaining in the body would retreat and continue to exist in its previous situation, re-forming the remainder. This Worm grows to the length of several yards.

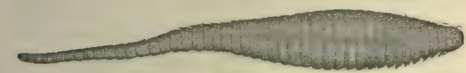


FIG. 534.—LINGUATULA TÆNIOIDES.

854. SECTION II. CŒLELMINTHA. A characteristic example of this group, in which the worm-like form is preserved, with a considerable degree of complexity of organisation, is the *Tænia*

Solium, or Tape-worm. The body of this animal is distinctly divided into joints or segments; which sometimes amount to several hundred; the whole animal occasionally attaining the

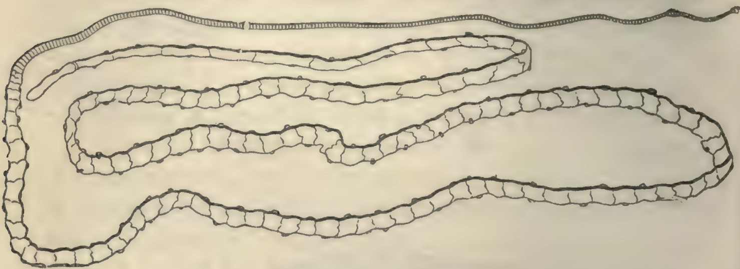


FIG. 535.—TÆNIA SOLIUM.

length of ten feet. These segments are all connected by the nutritive canal, which runs from one end to the other; but the reproductive apparatus is repeated in each division. The head is small, and possesses a double circle of small hooks. Its existence is essential to the life of the body, which dies if the head be broken off; but if some of the joints remain attached to the head, it continues to grow and form new ones.—The so-called *Eels* of vinegar and sour paste are referrible to this group, in regard to the simplicity of their structure and their worm-like form; although their habitation is so different. There is also a little worm-like animal closely allied to these, which is found in diseased ears of wheat, and which possesses remarkable tenacity of life, being revived by moisture after having been dried for almost any length of time.—The accompanying figure represents one of the Entozoa, in which the Vermiform aspect is almost completely wanting. This animal possesses a head much resembling that of the Tape-Worm; but instead of having a long jointed body, it dilates behind into a large bag, which contains only fluid. It does not frequent the cavities of the body, like the Intestinal

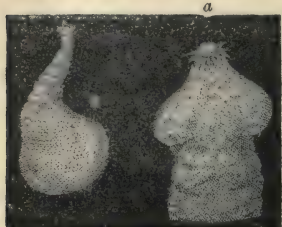


FIG. 536.—CYSTICERCUS CELLULOSÆ; *a*, head enlarged.

Worms; but is found in the areolar issue, and in the substance of the various membranes. It is not uncommon in Man; but frequently multiplies to a great extent in the Pig.

CLASS OF ROTIFERA.

855. The class of ROTIFERA, or *Wheel-Animalcules* and their allies, is probably to be regarded as belonging to the Articulated division of the animal kingdom; although the characters of that group are by no means distinctly marked in it. That these beings possess a structure much more complex than that of the Infusoria, to be hereafter considered (Chap. XXV.), there can be no doubt whatever. That this complexity of structure was for a long time overlooked, was owing to the minute size of the animals in question; scarcely any of them exceed a line in length, and many are less than $\frac{1}{500}$ of an inch. Nearly all the species of this class are aquatic in their habits, some living only in salt water, others frequenting stagnant ponds, and others appearing in vegetable infusions, where they generally succeed animalcules of inferior organisation. A few, however, can live in moist earth.

856. The great transparency of the bodies of the ROTIFERA permits their *general* structure to be easily recognised. They have usually an elongated form, similar on the two sides. At the anterior extremity, we observe one or more rows of vibratile *cilia*, usually arranged in a circular manner. When these are in motion, an appearance as of revolving wheels is produced, from which the class derives its appellation; and this is particularly evident in one of its commonest forms, usually known as the Wheel-Animalcule, which possesses a circular row of cilia on each side (Fig. 537, *b*). In many species we find a prolongation of the body in front, extending beyond the ciliary apparatus; this, which sometimes bears one or more red spots, that are believed by Ehrenberg to be eyes, may be regarded as a head (Fig. 537, *a*). The body is covered by a double envelope, both

layers of which are extremely thin and flexible in some species; whilst in others the outer one seems to possess a horny consistence, and may even contain siliceous or flinty matter, like the sheaths of the lower Infusoria. In the former case, the whole integument is drawn together in a wrinkled manner, when the body is shortened; in the latter, the sheath acts as a kind of cell, into which the head and ciliary apparatus can be completely retracted. These last would seem to have some relation with the Polypifera; and we shall hereafter see that the affinity may be regarded as very close. On the other hand, the former present an external resemblance to the Vermiform tribes; which, also, will be found to increase on a closer examination: and there are also species, of which the sheath bears a strong likeness to that of some Entomostracous Crustacea (§ 807). Hence we may regard this group as connecting the Articulated classes with the Zoophytes.

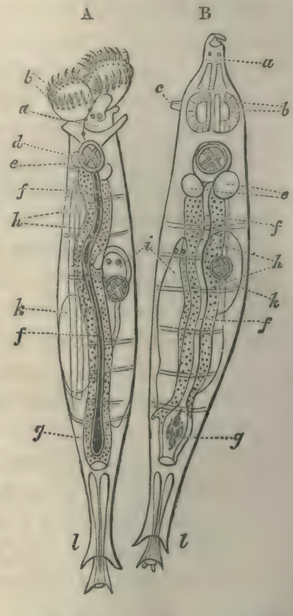


FIG. 537.—WHEEL ANIMALCULES; A, with the wheels expanded; B, with the wheels folded up and drawn in; *a*, the head with the eye-spots; *b*, the wheels; *c*, water-siphon; *d*, masticating apparatus; *e*, salivary glands; *f f*, intestinal canal; *g*, its dilated termination; *h*, glandular apparatus surrounding it; *i*, young ones nearly complete; *k*, eggs; *l*, tail.

857. As a characteristic illustration of the class, we shall select the common Wheel-Animalcule, *Rotifer vulgaris*. The body, when extended, possesses considerable length in proportion to its diameter, and has much of the Vermiform or Worm-like aspect; this is increased when a slight contraction draws the external membrane, which is here thin and very flexible, into transverse wrinkles, that seem to indicate the segments of the trunk. The posterior extremity is prolonged into a tail, possessing three

joints, each of which has a pair of prongs or points. These joints can be drawn up within each other, like the sliding-tubes of a telescope. Within the external integument there are four longitudinal bands running from end to end; these are probably bundles of muscular fibre, by the contraction of which the body may be shortened. The cilia are disposed in two circles, forming what are termed the *wheels*. By the successive vibration of these, the appearance of a continual rotation is produced; and their action creates rapid currents in the surrounding fluid, by which the supply of food is obtained. A sort of whirlpool is created by each wheel, which brings towards the mouth the minute animalcules and other particles floating in the neighbourhood; and those which are not swallowed, are carried off by a return-current. Between the wheels, the head is occasionally protruded, bearing the two red spots supposed to be eyes; and on its under surface there is a projecting spike (*c*), which is observed to be tubular, and which is believed to act as a syphon for the introduction of water into the general cavity, for the purpose of respiration. In the organisation of the alimentary canal, we observe a striking resemblance to that of the Ascidiform Polypes (Chap. XXIV.) The œsophagus terminates in a sort of gizzard, provided with regular teeth at its entrance (*d*). These teeth are two in number on each side, and are fixed upon hard jaws, moved by powerful muscles, so as to work between each other. All the food which is swallowed is submitted to their action, before it enters the first stomach; and when the cilia are in operation, these jaws are always in regular movement. From the first stomach there passes off in the *Rotifer* a long straight intestine (*f*, *f*), which terminates without any dilatation except near its close (*g*), just at the commencement of the tail. But in many other Rotifera we find the gizzard opening into a larger cavity, which may be regarded as the true digestive stomach. Near the termination of the intestine is the opening of the passages, by which are extruded the eggs (*k*), that are formed in the large ovaria. These eggs often attain so great a degree of development, while yet within the body of the parent, that the ciliary movements of the embryo may be seen; and the young may be

said to be born alive, being capable of active locomotion, and of obtaining their own food, as soon as they quit the body of the parent. Besides the longitudinal muscular bands, we observe transverse lines crossing the body at intervals, which might be supposed to possess the same character, and to contribute to the elongation of the body, by contracting upon the contents of the visceral cavity. But Ehrenberg gives strong reasons for the belief, that these are blood-vessels, passing off from a trunk which runs along the back, like the dorsal vessel of Insects (§ 618). Nervous ganglia are suspected to exist in this animal in the neighbourhood of the eyes; but they cannot be seen in this species as distinctly as in some other Rotifera.

858. This Animalcule, from the activity of its habits, and the variety of the movements it performs, is one of the most interesting objects which commonly present themselves to the microscopic observer. Sometimes it fixes itself by its forked tail to some solid basis, and then sets its wheels (as they appear) into rapid revolution; at the same time bending its flexible body in various directions, so as to create currents in different parts of the surrounding water. In this manner it draws into its gullet the unfortunate Animalcules which have been affected by the whirlpool it has created; just like (it has been amusingly remarked by Spallanzani) a certain species of Whale, which, after having driven herrings into a bay or strait, by a blow of its tail produces a whirlpool of vast extent and great rapidity, which precipitates them down its open mouth. The food thus taken in passes at once towards the stomach, and is submitted to the action of the jaws at its entrance, by which it is broken down. By keeping a Wheel-Animalcule for a few days in pure water, it will become almost perfectly transparent in every part, and its alimentary canal will be completely emptied. If some water containing the green or red *Cercariæ*, or any other small coloured animalcules be then added, its voracity will be very amusingly exhibited. They will be very distinctly seen passing into the alimentary canal, as fast as the animal can masticate them; and this will become distended with their coloured substance. It cannot be questioned that the ciliary movement is here entirely

subject to the will of the animal. When satisfied with the supply of food it has obtained, the movement of its wheels no longer continues; and the lateral projections on which they are situated then usually fold themselves inwards, so as to conceal them. The form of the animal—the head still projecting—then closely resembles that of a Leech; and the movements which the *Rotifer* performs in this condition, are by no means unlike those of that animal. Sometimes it detaches itself altogether, and swims freely through the fluid, as if in search of a new pasture. In other instances it attaches itself by the head, which is furnished with a sort of sucker for the purpose; and then, by shortening the body, draws up the tail into close proximity with it. It then attaches the tail, and, detaching the head, extends the body so as to project the head to a considerable distance, where it takes a new hold of the surface upon which it thus creeps. The rapidity and precision with which these movements are executed, display a considerable amount of muscular energy on the part of the animal, as well as of that capability of adapting its operations to circumstances, which indicates sensations of some acuteness. When the body is elongated to its full extent, the intestinal canal runs nearly straight; and the eggs, which may usually be seen by its side, lie apart from one another. But, when the body is contracted, the alimentary tube becomes serpentine, and the eggs by its side, appear to be in close contact. The great amount of muscular contractility, and the flexibility of the integument in this animal, enable it thus to contract itself more than most of its class. It is not unfrequently seen to assume quite a globular form; and this is its usual aspect when it dies, or when the water evaporates.—The reproduction of the Rotifer is not accomplished by spontaneous subdivision, or by the production of buds, such as we shall see to occur in the lower Infusoria; it takes place only by eggs, in the manner already mentioned. Although not many eggs are produced at once, yet these so speedily become capable of producing others in their turn, that the multiplication of these beings takes place with extraordinary rapidity. A calculation, made by Ehrenberg, from data furnished by experiments upon another species, will be presently given (§ 861).

859. The capability which these Animalcules possess, of being revived, after having been entirely dried up, or *desiccated*, is one of the most curious points in their history; since no other animals of an organisation so complex, appear able to preserve their vitality under the same treatment. The fact was first observed by Leeuwenhoëk; and it has been since confirmed by other observers. Ehrenberg doubts, however, whether a complete desiccation could have taken place; thinking it impossible that the animal should survive it. The following statement of my own experience on the subject may not, therefore, be undesirable. In the summer of 1835 I placed a drop of water, containing a dozen specimens of the *Rotifer vulgaris*, on a slip of glass; and allowed the water to dry up, which it did speedily, the weather being hot. On the next day, I examined the glass under the microscope, and observed the remains of the animals coiled up into circles,—a form which they not unfrequently assume when alive,—but so perfectly dry that they would have splintered in pieces if touched with the point of a needle, as I had before observed in similar experiments. I covered them with another drop of water; and in a few minutes ten of them had revived, and these speedily began to execute all their regular movements with energy and activity. After they had remained alive for a few hours, I again allowed the water which covered them to dry up; and I renewed it on the following day with the same result. This process I repeated six times; on each occasion one or two of the animals did not recover; but two survived to the last; and with these I should have experimented again, had I not accidentally lost them.—It is possible that the species on which Ehrenberg and other foreign naturalists have experimented, may not be the same as that which I and other English observers have used. Something, too, appears to depend upon the season and the general condition of the animal; for, on repeating the experiment in subsequent years, I have found the results extremely variable,—not more than one or two sometimes recovering, out of a large number that had been dried up. It is interesting to remark, that, whilst, in the embryo which is being developed from the egg, the rotatory and masticating organs are

the first parts which exhibit motion, they are the last to revive after this kind of resuscitation.

860. We observe, then, in the *Rotifer vulgaris*, a very manifest tendency to the Vermiform character, exhibited in the elongated shape of the body, the position of the eyes and mouth at one extremity of it, the narrow, straight, intestinal canal having its second orifice near the other extremity, and the mode of locomotion when the tail is detached and the operation of the wheels suspended. This tendency, however, is not so marked in some species of the class, which are in many respects more highly developed than this;—for example, the *Hydatina senta*, an animalcule not uncommon in vegetable infusions. Here the body is somewhat funnel-shaped; and the cilia are arranged around the wide mouth, in two concentric rows. The outer row consists of a simple continuous circle, arranged upon the edge of the body; but the inner one is made up of eleven groups of cilia, attached to distinct muscular lobes. The integument appears to consist, as in the *Rotifer*, of two membranes, both of which are soft and flexible. To the inner one are attached four pairs of longitudinal muscles, by which the chief movements of the body are performed. The tail has separate muscles for its retraction or protrusion; and others are seen at the large extremity of the body, which fold up the ciliary apparatus. The distinction between the muscles and the supposed vessels is here well marked; and there can be little doubt that the true function of the latter has been assigned, even though no subdivision or re-union can be traced (on account of the minuteness of the whole object) between the transverse

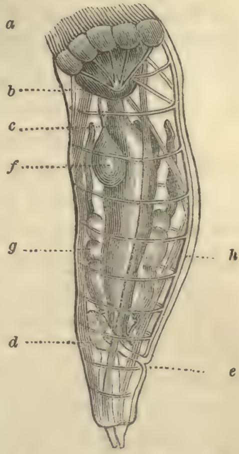


FIG. 538.—HYDATINA SENTA; *a*, rows of cilia; *b*, muscles of the jaws; *c*, stomach; *d*, enlarged termination of the intestine; *e*, anus; *f*, salivary glands; *g*, ovaria; *h*, dorsal vessel.

branches. The mouth is situated in the centre of the large extremity of the body; it leads, through a short œsophagus, to the first stomach or gizzard, the jaws at whose entrance are provided with five or six pairs of teeth. Into this cavity a pair of secreting cæca open; and between the termination of these is the commencement of the intestinal tube; the upper part of which, being very distensible, may perhaps be regarded as a second stomach, since in this the digestive process is principally performed. The intestine terminates, as in the *Rotifer*, near the posterior part of the body; and the oviducts open into the distended extremity of its tube. The nervous system is here easy to be distinguished. It consists of a kind of circle surrounding the œsophagus, on which three pairs of ganglia may be observed. From the lower pair there proceeds a double cord, which passes along the ventral surface of the body to its opposite extremity.

861. The reproductive powers of the *Hydatina* are very remarkable. The number of eggs contained in the ovarium at once is never large, seldom exceeding three or four; but they are frequently deposited and renewed, and themselves soon arrive at maturity. The following experiment is related by Ehrenberg:—"On Nov. 21, I placed in a jar a young *Hydatina* containing an egg nearly mature. I added for its food a drop of liquor containing Monads. On the morning of the 22nd, the egg had been deposited. On the 23rd I met with four individuals, of which two were fully developed. On the morning of the 24th, there were twenty. The observation ceased at this point; as it became too difficult to count the numbers which thus rapidly increased. In a space of 72 hours, twenty individuals had been formed—one only having been employed as the stock; and at this rate of increase, the numbers would be, at the end of ten days, 1,048,576; and this number would be quadrupled in another day. Even if only two instead of four were produced daily by each individual, a million would be called into existence in twenty days; and on the twenty-fourth day, we should have 16,777,216 animalcules." When we consider, in connection with this rapid increase in number, the curious power of revivification possessed by these

beings, it is obvious that we need not have recourse to the idea of spontaneous generation,* to account for their sudden appearance in various situations, and for their speedy multiplication wherever the condition, in regard to food, temperature, &c., is favourable.

* This term refers to an idea which has been entertained at various times, that animals of low organisation may *of themselves* originate, by the accidental meeting of particles adapted to form their structure.

CHAPTER XIV.

OF THE MOLLUSCA IN GENERAL.

862. Quitting now the *Articulated* series,—which we have seen to terminate in very simple forms of structure, that lead us towards the Zoophytes,—we return to a higher point in the Animal scale, to descend in like manner through the Molluscous series. Looking only at the general complexity of structure exhibited by these groups of Animals respectively, we might have some difficulty in deciding which should rank the highest; since in the Articulata we observe one set of organs far more highly organised than in any of the Mollusca; whilst the converse holds good as to another set of organs in the Mollusca. But when we look at the respective characters of these organs, we cannot reasonably hesitate longer. It is the organs of *animal* life that are so highly developed in the Articulata; whilst it is in the development of the organs of nutritive or *vegetative* life only, that they are surpassed by the Mollusca. In the Animal scale, therefore, we may justly regard the Articulata as ranking on the whole above the Mollusca. To the consideration of the latter group we shall now proceed.

863. The range of animal forms comprehended in the sub-kingdom Mollusca is so great, that it would be difficult to include them by any character common to all. We encounter but few traces of the circular disposition of organs around the mouth, which is characteristic of the Radiated tribes; and we seldom meet with any thing that even approaches to the elongation of the body, still less to the division into segments, which has been noticed among the Articulata. This will be comprehended, when it is borne in mind that the body of the Mollusca is almost entirely occupied by the organs of nutrition; and that the organs of sensation and locomotion are entirely subservient to

the supply of these. We find in the lowest tribes of this group, living beings which are fixed to one spot during all but the earliest period of their lives; and which scarcely possess within themselves so much power of movement, as that enjoyed by the individual polypes in a mass of Coral; and yet these exhibit a complex and powerful digestive apparatus, a regular circulation of blood, and an active respiration. But we nowhere find, throughout the whole animal kingdom, that the conformation of these organs *governs* the shape of the body; they rather *adapt* themselves to the type which predominates in its structure, and which is principally manifested in the disposition of the locomotive organs. Thus, the stomach of the Star-fish sends a prolongation into each ray; whilst in the Articulata, on the other hand, we find the digestive cavity prolonged into a tube, in accordance with the form which the body there possesses.

864. Thus we see that, in regard to external shape and arrangement, the apparatus of Organic life has no definite plan of its own; and in the Mollusca there is an absence of any general type, to which it may be made conformable. Hence the shape of the body varies extremely in those classes, in which it is entirely or principally composed of these organs; and no general character can be given, which shall apply to all, or even a large part, of the animals composing them. There is often an entire want of every kind of *symmetry;* that equality of the two sides, which is peculiarly characteristic of the higher animals, being deficient; as well as the radial arrangement of parts seen in the lower. But this is only the case, where there is no development of *a head;* that is, of a prominent part on which the mouth is situated, and which also bears the organs of sensation, if any exist. In the higher Mollusca, which possess not only sensory tentacula, but eyes, and even organs of smell and hearing, we find these disposed in a symmetrical manner; so that the head (where it exists), or the part peculiarly concerned in *animal* life, presents a bi-lateral equality of parts, even where the remainder of the body wants it. In the more active species among the higher classes, we find this bi-lateral symmetry extending in many instances through the whole body; evidently

bearing a pretty close relation with the degree of locomotive power. It is most evident and complete in the CEPHALOPODA; many of the animals in which class are adapted to lead the life of Fishes, and resemble them in the general form of the body and in the structure of many individual organs.

865. As a group, however, the MOLLUSCA are to be characterised rather by the *absence*, than by the possession, of a definite form; and there is a corresponding absence of any regular organs of support, by which such a form could be maintained. The name they have received designates them as *soft* animals; and this they are pre-eminently. The Shell, where it exists, is to be regarded rather in the light of an appendage designed for the mere protection of the body, and deriving its shape from it; than as a skeleton, giving attachment to muscles, and regulating the form of the whole structure. Where the body is entirely inclosed within it, as in the lower bivalve Mollusca, no locomotive powers whatever, except such as depend on the passage of water through the respiratory tubes, are enjoyed by the animal. It is only where the body is uncovered by a shell, or a portion of the body can be projected beyond it, that any active movements can be executed; and the muscles concerned in the performance of these do not make the shell a fixed point, as is done by those of Articulated or Vertebrated animals in regard to *their* skeletons, but are entirely unconnected with it.

866. Hence we see that the shell of a Mollusk is, when considered in reference to its functions, a very different organ from that of a Crustaceous animal, although formed in somewhat the same manner. Its frequent absence might of itself lead us to suspect its want of importance to the living structure. In one whole class of Mollusca it is entirely deficient; and in three others it is frequently absent. In only one it is universally present. When speaking of the anatomical conformation of the body, therefore, we may leave the shell pretty much out of consideration. Before the animals which produce them had been properly studied, Naturalists founded their classification of Mollusca upon the shells only; and the greatest confusion thus resulted. Shells

of very similar aspect are often produced by animals extremely unlike each other,* and living in different conditions—as, for instance, fresh and sea water. And shells of very dissimilar character in the eye of the mere Conchologist, often belong to animals closely allied. In fact, the form of the shell taken alone is a character as purely artificial, as the number of stamens and pistils in a flower; and will lead to a classification as far removed from a natural plan. But when the principal divisions have been formed upon other grounds, the conformation of the shell will often afford valuable subordinate characters; and the Naturalist seeks to employ these as much as he safely can, on account of the facility with which he can apply them to the study of those fossil remains, from which all traces of the animal itself have disappeared. The softness of the entire body of the Mollusca prevents us from recognising its form and structure after death, in any other way than by the shell; but upon this, it must be remembered, entire reliance cannot be placed, since it is liable to great variation, in accordance with the circumstances of the *individual*, whilst it is by no means certain that there are constant differences in its form in distinct *species*.

867. The only tribe of Mollusca which presents anything that corresponds to the internal skeleton of the Vertebrata, is that of the Cuttle-fish. There is in their bodies a cartilage, partly inclosing the nervous centres in the head, and sending prolongations along the back, for the protection of the large nervous cords which traverse it, and for the attachment of the muscles by which it is moved. These last are especially developed, where the body is spread out into fin-like processes, resembling those of Fishes, by the stroke of which active movements are produced (Fig. 540). This skeleton is almost as highly organised, as are the lowest forms of that internal skeleton which is characteristic of Vertebrata (§ 585).

868. In all the Mollusca, the soft body of the animal is

* The impossibility of founding a correct classification upon the characters afforded by the shell only, is made at once apparent by comparing the shell of a *Serpula* (Fig. 528), with that of a *Vermetus* (Fig. 583). Between these two shells, there is no essential difference; yet the animals which form them belong, not merely to different families, but to different sub-kingdoms.

inclosed in a spongy elastic skin, with which muscular fibres are interwoven; this is termed the *mantle*. This envelope is frequently not applied closely to the surface of the organs contained in it; especially among the lower classes, in which the space thus left constitutes a respiratory chamber. It has apertures for the admission and exit of the surrounding water, to effect the aeration of the blood; and, when the mouth is not capable of being projected beyond it, the same current furnishes the supply of food. These apertures are sometimes extended, for particular purposes, into proboscis-like tubes (Fig. 597). Where the head is capable of being protruded, there is usually an opening in the mantle for the purpose; and another for the foot, where it exists as a separate organ.

869. The *mantle* is chiefly interesting, as being the portion of the body alone concerned in the formation of the *shell*. Sometimes this envelope is secreted from nearly the whole surface; sometimes from only a small part of it. As the same general statements in regard to the constitution of this body will apply to all the Mollusca, its origin and essential characters may advantageously be described, previously to the more detailed account, which will be given of the several classes, in which its leading peculiarities of form will be noticed as they occur. Shells are formed, like bones, of a combination of earthy and animal matter. The former consists entirely of carbonate of lime, which is usually deposited in a crystalline condition. The latter is composed of layers of membrane, alternating with the mineral matter; and of cells inclosing it. The cellular structure, which seems to be of the nature of Epithelium (ANIM. PHYSIOL. § 39), is generally found upon the surface. If the carbonate of lime be removed by the slow action of a weak acid, the animal matter will remain, sometimes in the form of a continuous membrane, but sometimes only as a flaky mass, easily shaken into separate portions. The shell is most solid and massive in those species which lead an inactive life; and it attains greater weight in the Conchifera, in which every species forms a stony covering, than in the Gasteropoda, whose powers of locomotion are somewhat greater, and in which the shell is often absent,

and is frequently composed, where it does exist, of nothing but a thin horny plate, destitute of calcareous deposit.

870. As the mouth of the shell is always at its widest part, and as, in extending it, the cavity is enlarged as well as its entrance, there is evidently no necessity for such a division into separate plates, with a provision for the individual growth of each, as we have seen in the Cirrhopoda (§ 830); nor for the periodical exuviation and renewal which is performed by the Crustacea. In order to adapt its size to the progressive increase in the bulk of the body, new layers are deposited from the mantle at intervals, each of which usually lines the previous one, and extends beyond it. The portion which thus projects is generally thicker and firmer than the rest of the new layer; since that part which is deposited within the previous layers is protected and supported by them. And the corresponding part of the mantle is also thicker and more spongy, so as to possess almost a glandular texture. At this part of it, indeed, are situated the glands, by which the colouring matter is secreted, that gives to the exterior of the shell its beautiful and variegated tints; these are wanting in that portion of the mantle, which merely forms the lining to the older layers. In general we find each new layer in immediate apposition with the last; but this is not always the case. The animal forms it upon the mould, as it were, of its own body; and if this has shrunk, or changed its form, so as not to occupy the whole cavity of the shell, a space will intervene. This is remarkably shown in the *Spondylus varius*, or Water-Clam, a section of whose shell exhibits a regular series of chambers thus formed; and these are usually filled with water. In the common *Oyster* such spaces may often be observed; but they possess no regularity. The animal always appears inclined to adapt its shell to the form of the body, by reducing its cavity if necessary, as well as by extending it; and thus an *Oyster*, which has been kept without food, and whose body has thereby shrunk, so as not to fill the interior of the shell, will expend its last energies in forming a new layer adapting the interior surface to its altered condition. The texture of the shell varies considerably in the different tribes of

Mollusks; and it often furnishes characters in classification, which are equally useful with those derived from its form.

871. The means of locomotion possessed by Mollusca are usually very limited; and the absence of any constant and regular provision for this function, is an additional evidence how little it enters into the general plan of the group. We have seen in the Articulated series, that, wherever members or instruments for locomotion exist at all, they have the same character and situation,—being developed from the several segments of the body, with more or less complete uniformity. Now among the lowest Mollusca we shall find, that some tribes are entirely fixed, during all but the earliest period of their lives; that in others, although the body is not fixed, it has no other means of movement than that afforded by the respiratory currents, which cause it to advance gently through the water, without (as it would appear) any voluntary control on its own part. In many animals inhabiting *Bivalve* shells (*i. e.* Shells which are formed of two parts or valves, united by a hinge) there exists what is termed a *foot;* which is nothing else than a fleshy tongue-like projection, sometimes enabling the animal to leap upon hard surfaces, sometimes used as a boring apparatus, sometimes employed as a sort of fin for swimming, and sometimes chiefly useful as the instrument for producing the *byssus*, a sort of cord by which the animal attaches itself to rocks, &c.—In the animals inhabiting the greater number of *Univalve* shells, there is no such projecting foot; but the under side of the mantle is thickened into a fleshy disc, which, by its contractions and expansions, serves as an instrument of progression. This is well seen in the common Snail. Among the animals allied to these in structure, but not possessing a shell, the whole mantle is muscular; and by the contractions and expansions of its different parts, the general movement of the body is effected. This is especially the case with the aquatic species of this group; some of which are thus enabled to swim with considerable rapidity.—Again, in the Mollusca of the Cuttle-fish tribe, we find this method replaced by others, which are more efficient, but which are entirely different in their character. This group is distinguished

by the presence of a set of arms or members disposed in a circular or radiating manner around the mouth; and these arms are frequently the chief instruments of locomotion, as well as of the prehension of food, being furnished with a strong connecting membrane, that forms a sort of circular fin, by the aid of which the animal swims backwards (Fig. 545). In other members of this group, the arms are less developed, but the body is elongated into a fish-like form; and it is furnished at its edges with fins much resembling the dorsal and anal fins of Fishes, and supported by the cartilaginous internal skeleton already mentioned (Fig. 540). From this general sketch it is evident that the appendages for locomotion do not possess, in the Molluscous series, anything like the same regularity of development which they manifest in the two preceding; and that locomotion forms a much smaller part of the life they are destined to lead. In fact, the word *sluggish*, which is founded upon the well-known habits of a naked (or shell-less) terrestrial Mollusk, very well expresses the general character of the group in this respect.

872. The amount of development of the organs of sense in Mollusca, varies as much as the character of the locomotive apparatus. Thus in the highest class, comprehending the Cuttle-fish and its allies, the head is furnished with a pair of large well-formed eyes, constructed upon the general plan of those of Vertebrata. There is also an apparatus for Hearing, much resembling that which exists among the lowest Fishes; and there is reason to believe that an organ of Smell is also present. The senses of Taste and Touch appear to be very acute. It is in such animals, that we should expect to find the organs of sensation most developed, on account of their rapid locomotion and voracious habits. In the Gasteropods, which are not so much distinguished in these respects, we find the organs of sense less developed; but it is seldom that either of them is altogether absent.* Descending lower, however, we no longer find these organs situated upon a prominent part of the body; nor are they usually placed in the near neighbourhood of the mouth. This

* An apparatus for hearing, though of a very simple kind, has lately been detected in a large number of this class.

is usually furnished, indeed, with feelers or tentacula, which are nothing else than prolonged lips, and which serve to distinguish and select the food; but the eyes, if any are present, are generally placed elsewhere, in such a position as to be of the most effectual guidance in the movements of the body. In the lowest Mollusca, we lose all traces of any special organs of sense; and it appears as if the sense of feeling, possessed in all probability by the body in general, but peculiarly by the lips or tentacula, is the only one through which the animal can receive any information of its condition.

873. The conformation of the Nervous System is very much what might be anticipated from the facts just stated. It by no means displays the same complexity, or seems to possess the same importance as a prominent feature in the composition of a Molluscous, as it does in that of an Articulated animal; and its arrangement is not marked by any regular characters, but varies with the disposition of the organs with which it is connected. Thus we have a single ganglion, or a pair of ganglia, situated in the head, where this exists as a distinct part; and these ganglia, which seem to be the principal seat of the instincts of the animal, serve to direct those movements which are not *reflex*. The gills, the pharynx, the foot, and other organs, usually have their own distinct ganglia; and these, which are all connected with the *cephalic* ganglia (those situated in the head), seem to be the centres of the *reflex* actions of the several parts (ANIM. PHYSIOL. § 439, and ZOOLOGY, § 53, and Figs. 35 and 36). In the lowest Mollusca we find but a single ganglion, which seems in some degree to combine all the functions just mentioned, but to be particularly connected with the respiratory apparatus.

874. The Mollusca are, for the most part, extremely voracious; and are not particular in their selection of food. It is in those which possess most power of locomotion, that we see (as might be expected) the greatest exercise of choice; those which are dependent for their aliment upon the casual supplies brought by the sea, being obliged to take what they can thus get. Their digestive apparatus is always highly developed. We uniformly meet with a large liver; and frequently with salivary

glands, and organs of mastication. There is frequently a complete gizzard, or muscular stomach, for the reduction of the food, when this is not acccomplished in the mouth; and the intestinal tube is often of considerable length, and much convoluted, or rolled together. The blood is colourless or nearly so; and circulates, in all Mollusks, in a regular system of arteries and veins, issuing from a heart, which is usually muscular or nearly so, and possessed of two cavities, one of them a receiving cavity or *auricle*, and the other an impelling cavity, or *ventricle* (ANIM. PHYSIOL. § 257). The accompanying figure will give an idea of the usual mode in which the Circulation is carried on in this subkingdom. The blood (which has returned from the gills in an aerated state) is propelled, by the ventricle, *a*, through the main systemic artery, *b*; after passing through the capillaries of the system, it is collected by the systemic veins, *f*, into a large trunk, which again subdivides into the branchial arteries, *g*; these convey the blood, now rendered venous, to the gills, *e*, where it is aerated; and after returning thence by the branchial veins, *d*, it enters the auricle, *c*, whence it passes again into the ventricle, *a*.—The Respiration of Mollusks is almost always aquatic; being carried on by the aid of gills, which expose a large surface of blood to the water at once. These gills are sometimes altogether exterior to the body (Fig. 569); sometimes they are inclosed between folds of the mantle (Fig. 572); and sometimes the respiratory surface is altogether internal. In this

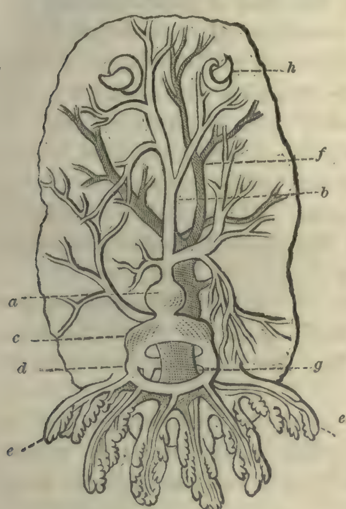


FIG. 539.—CIRCULATING APPARATUS OF DORIS.—*a*, ventricle; *b*, main artery or aorta; *c*, auricle; *d*, branchial veins; *e*, vessels of the gills; *f*, systemic veins; *g*, branchial arteries; *h*, tentacula.

last case it may be so disposed as to admit the flow of water introduced from without over its surface, as we shall see among the Tunicated Mollusks; or it may be adapted to expose the blood to the influence of air, as is the case among the Terrestrial Gasteropods (the Snail, Slug, and their allies), which are the only Mollusca not aquatic.

875. In the classification of the Mollusca, the system of Lamarck will be generally followed, with some modifications rendered necessary by the researches of others. The Sub-Kingdom may be first divided, like that of Articulata, into two principal sections;—the first including all those which have a distinct *head*, or (in other words) which have the mouth situated on a prominent part of the body, furnished with organs of special sense;—the second comprehending those in which no such head exists, the mouth not being capable of being projected beyond the body, and no organs of special sense being present. The former may be termed *Cephalous*, and the latter *Acephalous* (or headless) Mollusks. The Cephalous Mollusks are usually divided into the three following classes:—

I. CEPHALOPODA, which have feet or tentacula arranged in a circular manner around the head, as in the *Cuttle-fish* tribe. It is in this group, that we find the nearest approach to the Vertebrata.

II. PTEROPODA, a small but interesting class, characterised by the possession of a pair of wing-like expansions of the mantle, which serve as fins, and enable them to swim through the water with great velocity.

III. GASTEROPODA, which form the most extensive group of the whole Sub-Kingdom. These have a single foot, or muscular disc for locomotion, formed by a thickening of the mantle on the under surface of the body. Whilst the animals of the two preceding classes are entirely marine, there are species among these which are adapted to live in fresh water, and even on land.

We are probably to add to these the group of HETEROPODA, which has been usually ranked as an Order of the preceding, but which has been lately found to differ from them so much in internal structure, as well as in external form, as to be entitled

to rank as a distinct Class. They are especially distinguished by the form of the foot; which, instead of being a horizontal disc, is compressed vertically, so as to form a fin, which is turned upwards, like the dorsal fin of Fish, instead of being situated on the under side of the body.

876. In each of the foregoing Classes, we observe a considerable variation in regard to the relative size, and even the very existence of the Shell; for, whilst there are some species in all of them, which are entirely destitute of this protection (such being called naked Mollusks), there are others which possess it in a slight degree, having it generally concealed in a fold of the mantle; whilst in others, again, it completely envelopes the body when they desire to withdraw themselves under its protection. In nearly every case, the Shell, where it exists, is *Univalve;* that is, composed of but one piece.—In the Acephalous Mollusks on the other hand, we find two very distinct groups; in the first of which the shell is always present; whilst in the second it is as invariably absent. The first is therefore named *Conchiferous,* or shell-bearing; and the latter *Tunicated,*—the shell being replaced by a leathery or membranous tunic. The Conchiferous Acephala, with scarcely an exception, have *Bivalve* shells; and they are again divided into two classes, according to the arrangement of their respiratory organs.

IV. Lamellibranchiata, having the gills arranged in four *lamellæ*, or riband-shaped folds, which run parallel to the edges of the shell. To this group belong all the ordinary Bivalves.

V. Palliobranchiata, having the respiratory surface formed by the mantle itself. The animals of these shells differ in several other important particulars from the preceding. This class is very small at present, in comparison with the other Bivalves; but in the more ancient periods of the earth's history, a very large proportion of the Bivalve Mollusks seems to have belonged to it.

VI. Tunicata, a group including all those Acephalous Mollusks which are destitute of a shell. In this class, we find many points of structure, which lead us towards the higher Zoophytes.

CHAPTER XV.

OF THE CLASS OF CEPHALOPODA.

877. The Cephalopoda unquestionably constitute the group of highest organisation in the Molluscous sub-kingdom. They are characterised by the possession of *feet*, or locomotive organs, around the head; whence their name is derived. But these feet have no analogy either with the fleshy disc of the Gasteropods, or with the feet of Articulata or Vertebrata. They are, in fact, prolonged tentacula, or lips. In the Nautilus (Fig. 548), which approaches the nearest to Gasteropoda, they are very numerous, and are evidently feeble as instruments of prehension; whilst they would seem, from the distribution of their nerves, to be more concerned in sensation. On the other hand, this animal possesses a single fleshy disc, evidently analogous to that of the Gasteropods, on which it probably crawls, when moving along a solid surface, in a position analogous to theirs. In some of the Cephalopoda the feet are much prolonged, and of great power; and are evidently very important organs both of locomotion and prehension (Fig. 543). But in those forms which approach most nearly to Fishes, we find them again reduced in size, very much in proportion to the elongation of the body; and it is by the latter, and the fin-like expansions with which it is provided, that progression is then chiefly accomplished (Fig. 540). There are Fishes which possess tentacular prolongations of the lips, which are evidently analogous to the arms of the Cephalopoda; and this is one among the many interesting points, by which a transition is effected between these two classes. The Nautilus is the only one amongst existing Cephalopoda, in which the prin-

Fig. 540.—Calamary.

cipal part of the body is contained within a shell. Animals of this kind were formerly much more abundant. At present the *naked* species, as they are termed—in which the shell is rudimentary, and is inclosed between folds of the mantle instead of being external to the body—are the chief inhabitants of our seas. In some of these, the shell still retains considerable size and density, as the common pounce-bone; but in the long slender species, which swim by the movements of the whole body, it is necessarily flexible; and here we find it very narrow, and composed of a light horny substance, so as to bear some resemblance to a feather.

878. The trunk of these animals is inclosed in the mantle; which is shaped like a bag, sometimes nearly spherical, sometimes more or less elongated; inclosing all the viscera, and being only open in front (Fig. 541, *o*). The head, projecting from this opening, is round, and generally provided with two large eyes, of a structure very similar to those of Vertebrated animals. The mouth is situated in the centre of the circle of arms; and is armed with a pair of horny mandibles, which have very much the form of the Parrot's beak.

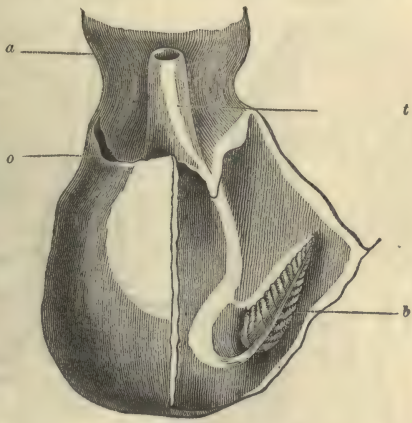


FIG. 541.—GILLS OF POULP.

—The arms are sometimes all of equal length, as in the *Octopus* (Fig. 545); and sometimes two are much longer than the rest, as in the *Calamary.*—Cephalopods are essentially aquatic, and breathe therefore by gills. These organs are concealed beneath the mantle in a particular cavity (Fig. 541), the walls of which dilate and contract alternately, and which communicates with

the exterior by two openings—one like a slit (*o*) for the entrance of the water—the other, for the exit of water and excrements, formed like a tube or funnel (*t*). Each gill (*b*) is shaped like a prolonged pyramid ; and is composed of a great number of membranous lamellæ, placed transversely, and fixed on both sides of a central stalk. The number of gills varies ; and this difference is characteristic of two great divisions, of which this Class is composed. In the Poulp, Cuttle-fish, and Calamary, there exists but a single pair ; whilst in the Nautilus there are two.

879. The heart is situated between the gills, on the median line of the body, and is composed of a single ventricle only (*c*, Fig. 542). The blood from the gills flows into this ventricle

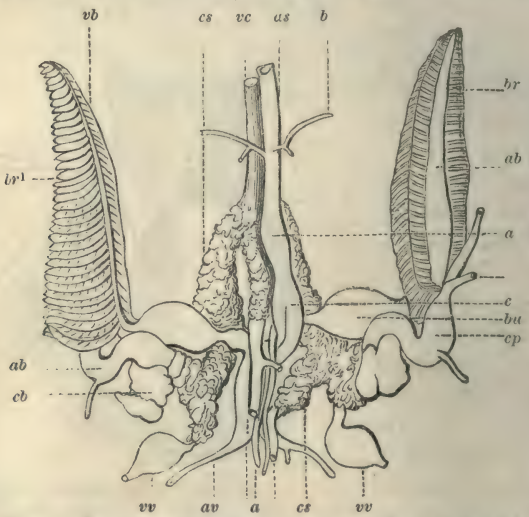


FIG. 542.—ORGANS OF CIRCULATION AND RESPIRATION IN CUTTLE-FISH.

by branchial veins (*vb*), whose openings are provided with valves; it then enters the arteries (*as*, *b*,) which spring from this organ, and is distributed into the body. This liquid then returns into a large vena cava (*vc*) ; which, when arrived near the heart, divides itself into two branches (*ab*) to enter the gills ; lastly, these vessels, when arrived at the base of the respiratory organs,

generally present remarkable dilatations (*cb*), interwoven with muscular fibres, so as to form two contractile reservoirs, performing the functions of *pulmonary hearts.* This arrangement is observable in all *Cephalopods* with two gills; but does not exist in those which are provided with four. It may be regarded as a transition-form between the heart of the lower Mollusca, which is altogether *systemic* (§ 874); and that of Fishes, which is entirely *respiratory* (§ 535).

880. The digestive apparatus is very complicated. The mouth is surrounded by a circular lip; and the parrot-like jaws are put in motion by powerful muscles. There are well-developed salivary glands, several stomachs, and a voluminous liver; the intestine terminates in the branchial cavity, at the base of the funnel by which the water is ejected, and communicates with a very singular secreting organ, which, in the *dibranchiate* (two-gilled) Cephalopods, produces an abundance of a black liquor, commonly termed its *ink*. The duct of this gland opens near the anus; and, when the animal is in danger, it expels this liquid through the funnel in sufficient quantities to hide the animal from the view of its enemies, by mingling with the surrounding water. It is the ink of one of these animals, the Cuttle-fish, which is employed in painting, under the name of Sepia; and several authors look upon Indian Ink as an analogous substance. — The four-gilled Cephalopods present nothing of this kind.

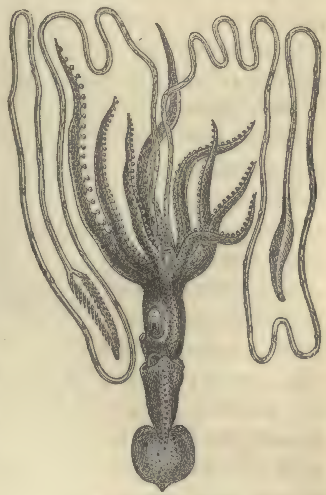


FIG. 543.—LOLIGOPSIS.

881. The arrangement of the organs of locomotion, which are fixed around the mouth, varies in different divisions. In the two-gilled Cephalopods, there is a crown of large fleshy tentacula, whose internal surface is provided with suckers, by means of

which the animal fixes itself with great force to any body which it embraces. In the Poulp we find eight of these appendages, and in the Cuttle-fish ten. Sometimes two of them are expanded into flattened membranes, as in the Argonaut (Fig. 546); or are elongated so as to become *filiform*, or threadlike, as in the *Calamary*, and particularly in the *Loligopsis* (Fig. 543). In the four-gilled Cephalopods these appendages are quite slender, and unprovided with suckers; but they are extremely numerous (Fig. 548).

882. Most Mollusca of this class are remarkable for the development and perfection of their eyes, which are exceedingly like those of Vertebrated animals. Many possess also an apparatus for Hearing; but this organ is reduced to a little membranous sac representing the vestibule, and receiving a nerve (ANIMAL PHYSIOL. § 512). Lastly, the nervous system of these animals

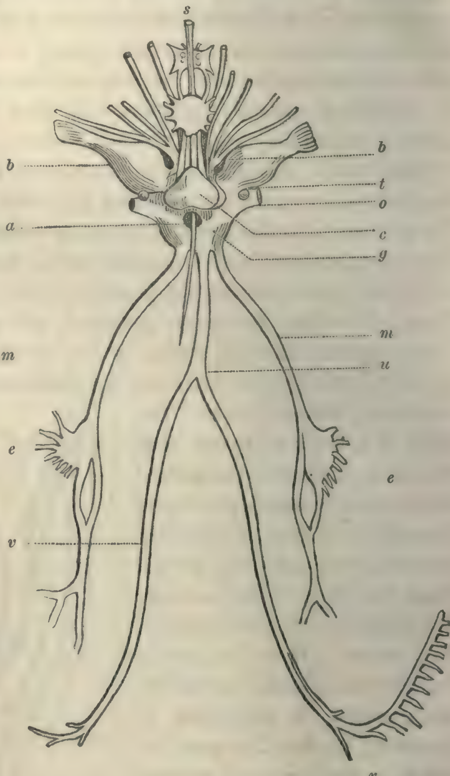


FIG. 544.—*a*, nervous collar embracing the œsophagus, the passage of which is marked by the bristle *s*; *c*, nervous mass, apparently analogous to the Cerebrum of Vertebrata, from whose under side proceed connecting cords to two ganglia situated in front, which send nerves to the mouth, lips, pharynx, &c.; *b*, tentacular ganglia, sending nerves to the arms; *o*, optic nerves; *g*, sub-œsophageal ganglion; *v*, great nerve of the viscera, of which one of the branches possesses an elongated ganglion, *r*, and enters the gills; *m*, another branch, having the same origin, and furnished with a star-shaped ganglion, *e*, that sends nerves to the mantle.

is more complicated than that of other Mollusks; and the different ganglia, situated around the œsophagus, tend more to unite in a single mass. The nervous collar thus formed is composed of a pair of cephalic ganglia, whence originate the optic nerves; of a pair of ganglia, situated more in front, but beneath the œsophagus, and furnishing the tentacula with nerves; lastly, of a pair of thoracic ganglia, supplying the mantle with nerves, and sending backwards two cords on each side, which are themselves furnished with ganglia, whence proceed nerves that supply the mantle, gills, heart, &c. It is evident from this description, that the nervous system of the Cephalopods approaches that of the lower Fishes in many particulars; especially in the almost complete concentration of the nervous centres in the region of the head, and in the presence of the rudiments of a cerebral mass. If the cords that proceed backwards from the sub-œsophageal ganglion had been united on the central line, instead of diverging from each other, they would have presented a strong analogy in position, as well as in function, to the Spinal Cord of Vertebrata.

883. Cephalopods are almost exclusively marine in their habits; only a few of them, such as the *Octopus* or Poulp (Fig. 545), ever quitting the water to prowl along the shore in search of food. When thus moving, they walk in what may be considered an inverted position; the mouth being downwards, and the opposite extremity of the body being directed upwards. When swimming, the Poulp moves backwards through the water, propelling itself by the alternate contractions and extensions of the circular fin, which unites the bases of the arms. But the long slender-bodied Calamaries (Fig. 540), in which the arms are short, swim much more after the manner of Fishes; striking the water, by means of the fin-like expansions of the mantle along the back and abdomen, with such force as occasionally to raise themselves out of the water. The Nautilus (Fig. 548) seems more limited in regard to its means of locomotion; since its arms are not long enough to serve as efficient instruments for this purpose, and it has no other means, except a fleshy disc, which resembles that of the Gasteropods, and which enables the animal to crawl along solid surfaces in an inverted position.

884. The animals of this Class are extremely voracious in their habits; and seldom, if ever, devour anything but animal food. They chiefly prey upon small Fishes and Crustacea; and seem especially destined to restrain the too rapid multiplication of the latter. Winding its arms around the body and limbs of even a powerful Crab, and securing them all by fixing its suckers upon their surfaces, the Cuttle-fish can pick the shell to pieces with its powerful mandibles, and extract the contained flesh, without fear of injury;—an action which no animal of any other Class could attempt. The firm armour, and powerful crushing jaws, of the more ancient Fishes, might have enabled *them* likewise to feed upon Crustacea; but no such Fishes now exist. The Common Cuttle-fish, and the Calamaries or Squids, are often very troublesome to fishermen, by following shoals of fish into the nets, devouring large quantities of them, and watching an opportunity to dart away before they can themselves be seized. In their turn, they become the prey of the larger Fish and of Cetacea. They are much used as baits in the Newfoundland Cod Fishery; and in the stomachs of the smaller Cetacea great numbers of the undigested horny Mandibles are frequently found, indicating (of course) that at least a corresponding number of the Cuttle-fish have been devoured by them.—Some species of this class attain a considerable size. The *Onychoteuthis*, the suckers on whose two long arms are furnished with hooks at their edges, has been known to attain the length of six feet; and it is much dreaded by the natives of the Polynesian islands, who are said to have been attacked by it, when diving for shell-fish.

885. The Class of Cephalopoda may be divided into two Orders, according to the number of the gills (§ 878);—the DIBRANCHIATA, or *two-gilled*, including the Cuttle-fish, Argonaut, and their allies, having only one pair of those organs;—and the TETRABRANCHIATA, or *four-gilled*, including only the true Nautilus among the existing Cephalopods, but comprehending a vast number of species now extinct, possessing four of those organs. The latter of these Orders is the one most allied to the Gasteropoda, both in the structure of the shell, and in the conformation of the animal.

Order I.—DIBRANCHIATA.

886. The species of the Dibranchiate Order are extremely numerous; and they frequent every part of the ocean, from the arctic to the equatorial regions,—some preferring the neighbourhood of the shores, whilst others are found only in the open sea. None of them possess more than *ten* arms, and a part have only *eight;* the latter are considered as forming the highest group, being the most removed from the Tetrabranchiate Order. In only one genus, the *Argonauta*, do we find the body inclosed in an external shell; in all the rest, the shell, or that which represents it, is internal, or rather is included between two folds of the mantle; and it serves rather as an organ of support, than as a protection to the animal.

887. To the *Octopod*, or eight-footed family, belongs the

Fig. 545.—Octopus or Poulp.

common *Octopus* or Poulp (Fig. 545), which is common on the southern coasts of Europe, and which is occasionally met with on our own shores. This animal is the *Polypus* of ancient

Naturalists; who were quite unacquainted with the animals to which the name is now restricted. (Indeed this name was first conferred on the *Hydra* and its allies, on account of their similarity in form, and in the position of their prehensile arms or feet, to the animal previously known under that appellation.) The common Poulp has arms six times the length of its body; and each of these is furnished with 120 pairs of suckers. Every sucker is composed of a circular adhesive disc composed of a muscular membrane; this has a thick fleshy circumference, and presents a number of lines radiating towards the circular orifice of an inner cavity, situated beneath the central part of the disc. In this cavity is a moveable circular piston; which, when the sucker is not in action, appears level with the circular aperture; but which, when the disc is closely applied to any object, is strongly drawn back, so as to increase the size of the cavity and produce a vacuum in it;—forming, in fact, an air-pump of the most precise and beautiful construction. When the animal releases its hold, it relaxes the muscles that drew back the piston; and the vacuum is then made to cease. The whole apparatus might be compared to a boy's leather-sucker, with an exhausting syringe fitted to its centre.

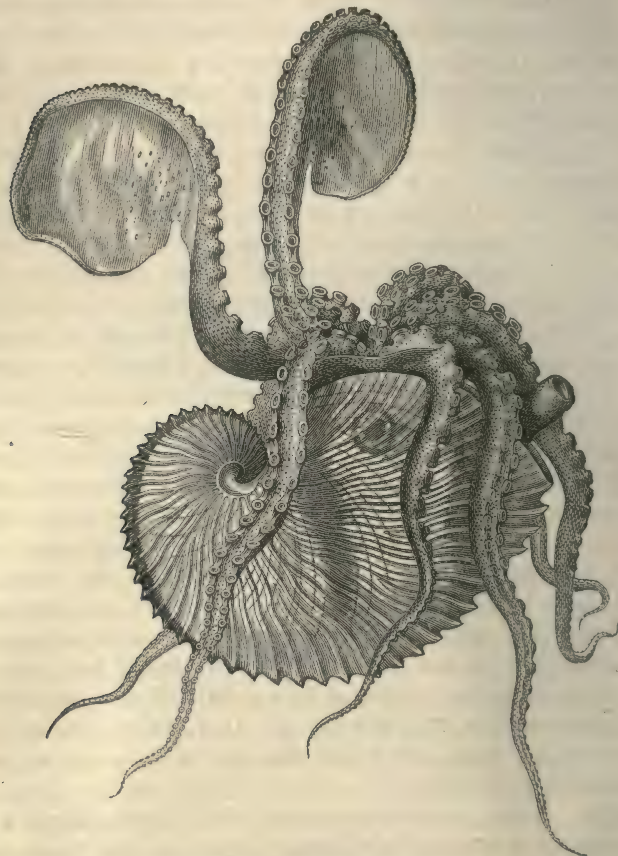
888. It may be noticed, as a curious example of reflex action, that the nervous trunk supplying each arm of the Octopus, is furnished with a series of ganglia, corresponding in number and position with the suckers. A part of the trunk passes over the whole series of ganglia without entering them,—precisely as in the case of the ventral cord of the Articulata (ANIM. PHYSIOL. § 442); and this sends branches into each sucker, so as directly to convey to them the influence of the cephalic ganglia, and thus to cause them all to contract at the will of the animal. On the other hand, each sucker receives nervous filaments from its own ganglion; and may be made to contract, when stimulated to do so, by the contact of a solid substance, even though the arm is entirely separated from the body. Hence, when a Cuttle-fish has fixed itself upon any animal, it may be cut into pieces without the suckers relaxing their hold; since the muscles of every sucker are called into action by the reflex properties of its own

ganglion alone. The conformation now described is common to the whole Order.

889. In regard to the Poulp it has been justly remarked, that "there is something strange and uncouth in the aspect of this creature; its long flexible arms moving and curling in all directions; and its large eyes, which stare with fixed gaze, rendering it even repulsive." Even a cursory observer would predict it to be ferocious and carnivorous; and its actual character harmonises with its appearance. Woe to the Fish that is infolded within the tenacious grasp of its arms. Resistance is vain; for the suckers adhere with such tenacity, that they may sooner be wrenched off than unfixed. Closer and closer to the mouth is the victim brought; until, being firmly secured as in a vice, the work of demolition commences.—Although the largest *Octopi* of which we have any account that is entirely free from doubt, do not measure above 4 feet between the ends of the arms; yet the inhabitants of several parts of the warmer regions of the globe confidently assert, that much larger ones are to be met with. These are said to extend their arms out of the water, and thus to lay hold of men, or of the masts of small vessels. The inhabitants of some of the islands in the Indian Archipelago are said to affirm, that Cuttle-fish are often seen two fathoms (12 feet) broad over their centre, with arms nine fathoms (54 feet long); and are stated to provide themselves with axes, whenever they go out in boats, from their fear of being seized by these monsters. Allowing for a great deal of exaggeration in these accounts, it is still probable that Octopi exist in the open sea, of much larger size than any with which we are familiarly acquainted.

890. A very interesting species of the Octopod group is the *Argonauta*, commonly called the "Paper-Nautilus," from the whiteness and delicacy of its shell. As the animal has little in common with the true Nautilus, it would be much better if the latter designation were entirely abandoned, and that of "Argonaut" substituted for it. The shell is not chambered, as in the true Nautilus; but possesses one spiral cavity, into which the animal can withdraw itself entirely. The animal, however, has

no muscular attachment to its shell; whence it has been supposed by many Naturalists to be a parasitic inhabitant, which



546.—ARGONAUT, OR PAPER-NAUTILUS.

had taken up its abode within it; the shell, from its resemblance to that of the *Carinaria* (Fig. 901) being imagined to have been really formed by an animal allied to that genus. It has been lately proved, however, by the interesting experiments of

Madame Power (who has kept a number of these animals in a kind of cage inclosed from the sea in the bay of Messina), that the shell increases regularly with the growth of the animal; and that the Mollusk possesses the power of repairing the shell when injured, in a manner corresponding to its original formation; whence no reasonable doubt can exist, that the Argonaut is the real construction of it.

891. Of the eight arms of the Argonaut, six taper gradually towards the extremities; but two are expanded into wide membranous flaps. From very early times, this animal has been reputed to swim on the surface of the sea, using its arms as oars, and spreading these expanded membranes as sails, so as to be wafted along by the wind. But it is now known by accurate observation of the living animal, that this is altogether a fiction (though an interesting one); and that the expanded membranes are spread over the sides of the shell, meeting along its keel or edge, and completely inclosing it. It is by these, indeed, rather than by the surface of the body itself, that the calcareous secretion is poured out, for the enlargement or reparation of the shell. It will be observed that there is a double row of suckers along the edge of each of the expanded arms; and by these suckers they are held in close contact with each other along the keel of the shell. When the animal withdraws its whole body into the shell, the exterior of the latter is about half uncovered, the expanded arms also being partly drawn in. By the action of the arms, the Argonaut can swim backwards in the same manner as other Octopi; and it can also creep along the bottom of the sea.—There is a fossil genus, *Bellerophon*, abundant in the mountain-limestone formation; which, from the characters of its shell, is regarded as nearly allied to the Argonaut.

892. The *Decapod* family, which, besides the eight ordinary arms, has two longer and slenderer ones, presents many points of approach to the Tetrabranchiate Order. This affinity is indicated, not merely by the increased number of the external arms, but by their smaller size in proportion to the body, by the frequent development of a second row of small tentacula within the others, and by several internal characters, especially the

development of a chambered shell, of which we find some traces in most of the different forms included in it. To this group belong the *Loligo*, or Calamary (Fig. 540), already several times noticed; the common *Sepia*, or Cuttle-fish, whose body is more bulky in proportion to its length; the *Loligopsis*, so remarkable for the length of its additional pair of arms (Fig. 543); and several others having the same general form. In all these, the only rudiment of a shell is a straight flat body, sometimes broad and firm, as in the Cuttle-fish (forming the *pounce-bone*, which may be picked up on every coast), sometimes slender and horny, as in the Loligo.—There is an existing genus, however, in which a chambered shell exists, very strongly resembling those of the Ammonite (Fig. 549) in general form, but completely inclosed by the animal, so as to become altogether *internal;* this is the *Spirula*, an inhabitant of tropical seas, whose delicate little shell may be picked up on almost any sandy shore in warm latitudes. The animal has not yet been very carefully examined; but it is known to possess no more than ten arms; whence its position is fixed as belonging to this group, rather than to the succeeding Order.

Fig. 547.—Belemnites; *a*, large extremity, showing the insertion of the chambered cone into the sheath.

893. With this family we are to associate an extremely interesting genus, the *Belemnite*, whose remains abound in several of the older rocks, especially the Lias and Oolite. The shell consists of a conical chambered portion, implanted (as it were) into a corresponding hollow of a long solid sheath, tapering to a point at its lower extremity (Fig. 547). The conical chambered portion extends considerably beyond the hollow of the stony sheath; but the border of the latter seems to have been prolonged

forwards in a horny condition, so as still to envelope the chambered cone. In the last or largest chamber of the cone, distinct remains of an ink-bag have been frequently met with; from which it has been argued, that, notwithstanding the strong resemblance of the shell to that of many genera allied to the true Nautilus and belonging to the *Tetrabranchiate* group, the animal must have been *Dibranchiate*, and must have included the shell together with its massive sheath, in the same manner as the Cuttle-fish included the pounce-bone. This argument was founded upon the fact, that the Nautilus—the only Tetrabranchiate Cephalopod now living—possesses *no* ink-bag; its power of withdrawing the body completely into its shell, rendering such a means of protection unnecessary: and its justice is made evident by the recent discovery of specimens of Belemnite, in which the soft parts of the animal are so well preserved, as to enable their form and general structure to be distinctly traced. From these it has been ascertained, that the arms were furnished with hooks, as in the *Onychoteuthis;* and that the body had a pair of small lateral fins situated at about the middle of its length. From the weight of its dense internal shell, the Belemnite may be supposed to have commonly maintained a vertical position; and, as its chambered portion was provided with a *siphuncle* analogous to that which we find in the *Nautilus* (§ 894), the animal probably had the power of ascending and descending in the water with facility. It would rise swiftly and stealthily to fix its claws in the belly of a fish swimming at the surface above; and then, perhaps, as swiftly dart down and drag its prey to the bottom, and devour it. We cannot doubt that, like the hooked Calamaries of the present seas, the ancient Belemnites were the most formidable and predaceous of their class.

The fossil Belemnites called "thunderbolts" ... in the ... Thus ... [illegible]

Order II.—TETRABRANCHIATA.

894. From the remains preserved in a fossil state, the Cephalopoda of this Order appear to have been formerly most abundant in our seas; as they present themselves throughout almost all marine strata, from the very earliest of the Palæozoic series, to those of a comparatively recent epoch. Yet some causes, of which we are at present ignorant, have produced the almost entire extinction of the Order; the only existing representative of it being the *Nautilus pompilius*, or Pearly Nautilus, so named

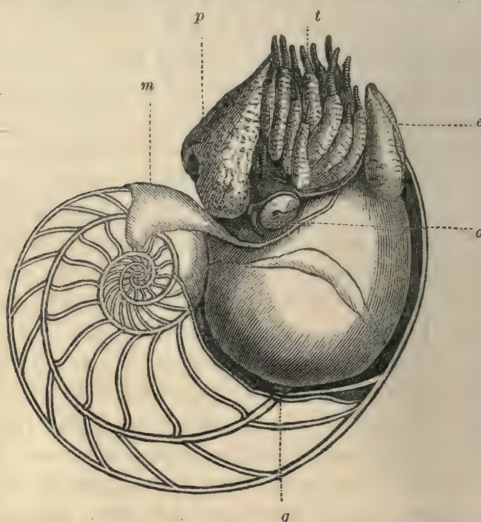


Fig. 548.—Pearly Nautilus; with the shell laid open; *t*, tentacula; *e*, funnel; *p*, foot; *m*, portion of mantle; *o*, eye; *g*, siphon.

from the nacreous lining of its shell. The shell of this animal is well known; being found on most shores between the tropics. Of the animal which constructs it, however, Naturalists had, until recently, the most vague and incorrect ideas,—the Nautilus being very rarely met with in the living state, owing to its being

an inhabitant of the open sea, and possessing the power of sinking at the slightest alarm. The general structure of the shell, which may be taken as a type of the whole group of *chambered* shells, will be evident from the accompanying figure; which represents it laid open. Externally it presents nothing remarkable, being a flattened spiral; but when its interior is examined, it is found to be divided into chambers, by a large number of transverse partitions of shelly matter. The outer chamber is by far the largest, and to this the body of the animal is restricted; but it maintains a connection with the rest by means of a membranous tube, called the *siphuncle* (*g*, Fig. 548), which passes down through a perforation near the centre of each partition, and thus penetrates even to the innermost and smallest chamber. Although the history of the growth of the Nautilus cannot (for want of a sufficient number of specimens) be positively stated, there is every reason to believe that, at the usual period for the enlargement of the shell, the animal adds to the edges of the outer chambers, in such a manner as at the same time to prolong and widen it; and that it then throws a new partition across its lower or inner part, so as to form an additional chamber. Hence the number of chambers would vary in different specimens, according to their respective ages, and the consequent number of additions they have made to their shells; and this is found to be the fact.

895. The general structure of the animal is intermediate between that of the Dibranchiate Cephalopods, and that of the Gasteropods. The arms are very numerous, amounting to nearly a hundred; they are unprovided with suckers, and they are short and slender, closely resembling the tentacula of many Gasteropods. The head supports a large fleshy disc; upon which it is believed that the animal can crawl over the bottom or shores of the ocean, as a Snail upon its foot. The power which the Nautilus possesses, of rising and sinking in water at will, has been attributed to the chambered structure of its shell; and to a power which it has been supposed to possess, of *diminishing* its bulk, by forcing water from the sac which surrounds the heart into the siphuncle,—or allowing it to be expelled from that tube

by the elasticity of the air in the chambers, when it desires to *increase* the bulk of the soft parts of its body. If such increase and decrease in *bulk* could be effected without any change in the *weight* of the whole mass, it would be caused (according to well-known principles of Hydrostatics) to ascend or descend in water; the animal with its shell being altogether of so nearly the same specific gravity with that fluid, that a very slight difference in this respect may produce either effect. But this theory, however ingenious, is inconsistent with the fact that, in some of the fossil chambered shells of this group, which we only know from their fossil remains, the siphuncle was evidently continued as a shelly tube throughout, and therefore could not have been distended with fluid; and even in the recent Nautilus, it does not appear to have been possessed of sufficient elasticity, to admit the action thus assigned to it. The use of the chambered structure, and of the siphuncle, therefore, still remains unknown.

896. The numbers of Fossil chambered shells formed on the same plan, and therefore probably to be regarded as the remains of Cephalopods of similar organisation, is very great. Thus we find in almost all marine strata, from the oldest limestones and sandstones of the Silurian system, down to those covering the chalk, large numbers of shells, very nearly resembling the existing Nautilus, and therefore called *Nautilites*. Another fossil genus, the *Orthoceratite*, had a chambered shell, formed upon the same plan with the Nautilus, but *straight* instead of being spirally curved. In these two genera,—as in some others allied to them, and forming the family NAUTILIDÆ, the partitions or septa between the chambers are smooth or simple;—that is, although they are rather concave on the surface which looks towards the outer chamber, and similarly convex on the other or inner side, they have no inequality or irregularity of surface. Moreover, in both instances, they are usually perforated by the siphuncle nearly in their middle.

897. In the spiral and straight shells which form the family AMMONITIDÆ, on the contrary, the partitions are very sinuous or wavy, sometimes even forming sharply-bent or zig-zag lines (Fig. 549); and the siphuncle usually runs along the outer edge,

and may be seen projecting from the surface. The *Ammonites*, commonly called Snake-stones, are among the most abundant of all fossils; especially in the Lias, Chalk, and Oolite formations. Their size is sometimes very considerable; Ammonites being occasionally met with of as much as four feet in diameter; and a diameter of three feet being by no means uncommon. In some places they are so numerous, that the rocks seem (as it were) composed of them alone. Above two hundred species of these shells have been already described; and it appears that many of these were very widely distributed. Thus two species of Ammonites found in the Himalaya mountains, at a height of 16,000 feet above the sea, are identical with species which are common near Lyme in Dorsetshire. These animals must have evidently been very important agents,—their carnivorous habits being duly considered,—in keeping the balance among the other tenants of the seas, by preventing the excessive multiplication of Crustacea, as well as (in all probability) of other Mollusks, and of Fishes. That their mouth was armed in the same manner as that of the existing Cephalopods, is evident from the fact, that *Rhyncolites*, or fossilized beaks, are found in large numbers, associated with the shells of the Ammonites, in the beds in which they occur. It has been suspected by some Naturalists, that the Ammonite might have been, like the existing Spirula (§ 892), an *internal*, not an external shell. This idea, however, is inconsistent with the size of the outer chamber, which is quite large enough to receive the animal, usually forming two-thirds of an entire whorl or turn of the shell; and also with the fact that the mouth of the shell, in specimens in which it has been found perfect, is so constructed as to have been evidently connected with the *external* parts of the animal, and not to have furnished attachment to internal organs. The shells of the Ammonites seeming to have been thinner than those of the Nautilites; and as their form was less

Fig. 549.—Ammonite.

arched, they would have been less capable of resisting pressure if they had not been furnished with *ribs* and *bosses*, variously disposed in the different species, for the purpose of strengthening them. In the species represented in the accompanying figure, these ribs are very prominent.

FIG. 550.—AMMONITES.

898. Several kinds of chambered shells, with sinuous partitions, are met with in various strata. These seem to have borne the same relation to the Ammonite, as the Orthoceratite to the Nautilus; and they have been arranged, according to their minuter diversities of structure. Some of them are spirally curved, but the several whorls or turns of the spire are not in contact with each other; this is the case with the *Crioceratite*. Others are straight, or but slightly curved; such as the *Baculite*. The *Turrilite*, again, has more of a corkscrew curve, resembling that of many Gasteropod shells.—There is good reason to believe that this group, which most abounded at the period when the Ichthyosaurus and Plesiosaurus were the principal inhabitants of the sea and shores, was preyed on by those marine tyrants; the remains of the beaks, and even of the horny rings surrounding the suckers, of Cephalopods, having been found in the fossilized excrement of those Reptiles.

CHAPTER XVI.

OF THE CLASSES OF PTEROPODA AND HETEROPODA.

899. NOTWITHSTANDING the small size of the class PTEROPODA, it is interesting in many particulars. It may be regarded as *representing*, in the sub-kingdom Mollusca, the Birds of the Vertebrated sub-kingdoms, and the Insects of the Articulated series; and the inconsiderable number of distinct forms which it presents, may probably be accounted for by reverting to the wide departure from the usual Molluscous type, which the animals of this class exhibit in their structure and habits. They are particularly distinguished by the possession of a pair of fin-like

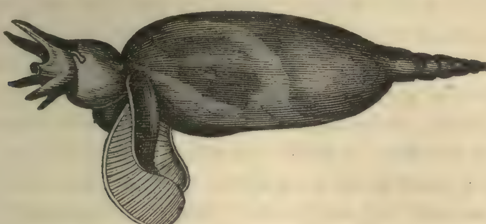


FIG. 551.—CLIO BOREALIS.

organs, or wings, consisting of an expansion of the mantle on each side of the neck, and furnished with muscular fibres; by the aid of which instruments, they can be rapidly propelled through the water. The body is uniformly symmetrical; that is, its two sides precisely correspond,—a condition evidently favourable for rapid movement. It is from the wing-like character of these lateral appendages, that the name of the class, which means wing-footed, is derived. Although the number of *species* belonging to this Class is small, and their dimensions are

inconsiderable, yet the number of *individuals* which associate together in shoals is often enormous, so that the sea appears literally alive with them. Some of them are possessed of a shell; whilst others are unprovided with such a protection. Where it exists, it is very light and delicate; and it seldom covers more than the posterior half of the body (Fig. 552). In one beautiful little Mollusk, the *Cymbulia*, it has the form of a slipper; from the large opening of which, the wings or fins are put forth. The head of these animals is usually prominent, possessing eyes and sensory tentacula; and their internal organisation is of a very complex nature.

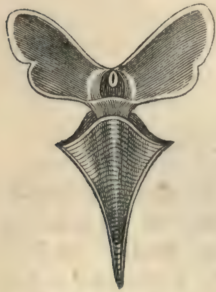


FIG. 552.—HYALÆA.

900. The *Clio* (Fig. 551) is one of the best-known genera of this class; and its general aspect conveys a good idea of that of the whole group. One species of this genus, the *Clio borealis*, abounds in the Arctic seas; presenting itself in such vast numbers, that, when the weather is calm, the surface appears covered with them for miles together; and an analogous species, the *Clio australis*, appears to be equally abundant in the polar regions of the southern hemisphere. These animals are well known to the whale-fishers and others, as *whales' food*, being among the chief articles on which that monster,—the largest existing animal,—is supported. It has been asserted that the sea is sometimes so glutted with the Clios, that the Whale cannot open its mouth without ingulphing thousands of them.—The chief point of special interest in the structure of the Clio, is the conformation of its organs for the capture and mastication of its food. The six tentacula, which are seen to project from the head, and which appear at first sight to be merely fleshy appendages, are in reality instruments of prehension, most elaborately constructed. Each of these six appendages, when examined attentively, is seen to be of a reddish tint; and this colour, under the microscope, is found to be dependent upon the presence of numerous minute isolated red points, distributed over its surface.

When still further magnified, these distinct points are evidently peculiar organs, arranged with great regularity, so as to give a speckled appearance to the whole of the conical appendage; and their number, at a rough guess, may be estimated to be about 3000 on each. When very minutely examined, every one of these specks is seen to consist of a transparent cylinder, not unlike the cell of a polype, and containing within its cavity about twenty sucking-discs, mounted upon stalks, by which they can be made to project beyond the edge of their sheath, so as to apply themselves to their prey. Thus, therefore, the head of one Clio will bear about ($3000 \times 20 \times 6$) 360,000 of these microscopic suckers; an apparatus for prehension, which is, perhaps, unparalleled in the whole animal kingdom. In this manner, these active little animals are enabled to seize and hold their minute prey; and their mouths are furnished with efficient instruments for reducing it. The jaws, which are placed *laterally*, as in the Articulata, are furnished with long sharp comb-like projections or teeth; and the tongue is beset with a vast number of sharp spiny hooklets, curved backwards. Besides the prehensile appendages just mentioned, two sensory tentacula are capable of being put forth, for the purpose of feeling for the food. The Clio possesses eyes, which, though extremely minute, have a very complete organisation; and altogether its structure completely corresponds with what has been already remarked in regard to the character of the Class, as the Molluscous representative of Birds and Insects.

OF THE CLASS OF HETEROPODA.

901. The Mollusks of this class (which has been generally considered as an Order of the Gasteropoda, but of which late researches appear to require the removal to its present position) are distinguished from all others by the structure and position of the foot. This, instead of forming a horizontal disc more or less flattened, is compressed, so as to constitute a vertical mus-

cular paddle, serving as a fin. The edge of this, in many species, is somewhat dilated at one part; forming a kind of sucker, by which the animals can attach themselves, and which seems to be a rudiment of the expanded foot of the Gasteropods. The gills are external, and form plume-like tufts, situated at the hinder part of the back. The body is gelatinous in its consistence, and so transparent as to permit much of its interior organisation to be seen. The mouth is furnished with a sort of muscular tube or proboscis, which can be protruded or drawn in at will; and it contains a rasp-like tongue.—One of the most remarkable

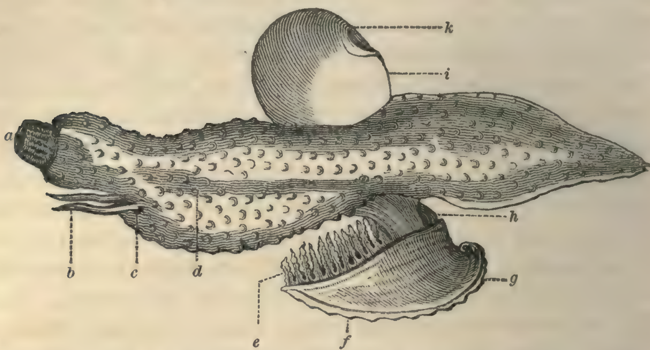


FIG. 553.—CARINARIA; *a*, mouth; *b*, tentacula; *c*, eyes; *d*, stomach; *e*, gills; *f*, anus; *g*, shell; *h*, liver; *i*, foot; *k*, sucker.

genera of this group, is the *Carinaria;* which possesses a thin shell, not unlike that of the Argonaut in form (§ 890). This shell protects the heart and liver; the gills float around its edge, and the intestinal canal terminates in its interior.—All the known animals of this group are inhabitants of the warmer-temperate, and tropical seas; many of them are found in the Mediterranean. Their general form and structure correspond very closely with those of the Carinaria.

CHAPTER XVII.

OF THE CLASS OF GASTEROPODA.

902. GASTEROPODS are those Mollusca, which are provided with a head, and which move from place to place by means of a fleshy disc, or foot, placed under the abdomen. This Class, represented by the Snail, is extremely numerous; and is chiefly composed of animals living in a univalve shell, which is usually cone-shaped and rolled into a spiral. Some species, on the contrary, are perfectly *naked,* or destitute of shell: the Slug, for example. The body is elongated, and terminates in front by a head more or less developed, bearing the mouth, which is provided with fleshy tentacula varying in number from two to six; the back is enveloped in a mantle, which is more or less prolonged backwards, and which secretes the shell; and the belly is covered on its under side by the fleshy mass of the foot. The viscera, lodged on the back, occupy the superior part of the buckler or cone formed by the shell, and always remain inclosed there; but the head and foot project beyond it, when the animal unfolds itself for the purpose of walking; and re-enter the last turn of the spiral, when it again contracts. Hence the size of this last part of the shell, and the form of the opening, are in keeping with the size of the foot. In most aquatic Gasteropods whose shell is spiral, there is a horny or calcareous disc, called the *operculum* (Fig. 555, *o*), which is attached to the posterior part of the foot, and which closes the entrance of the shell when the animal withdraws itself.

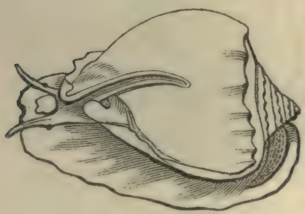


FIG. 554.—CASSIS.

903. The heart is always *systemic* (ANIM. PHYSIOL. § 281), and is composed almost invariably of a ventricle and an auricle (Fig. 539); it is placed near the back of the animal, opposite that side occupied by the reproductive organs.—The organs of Respiration are formed in some instances for aerial, in others for aquatic, respiration. In the first case they consist of a cavity, on whose walls the blood-vessels form a complicated net-work; and into the interior of which the external air penetrates, through an orifice in the outer border of the mantle. This pulmonic, or

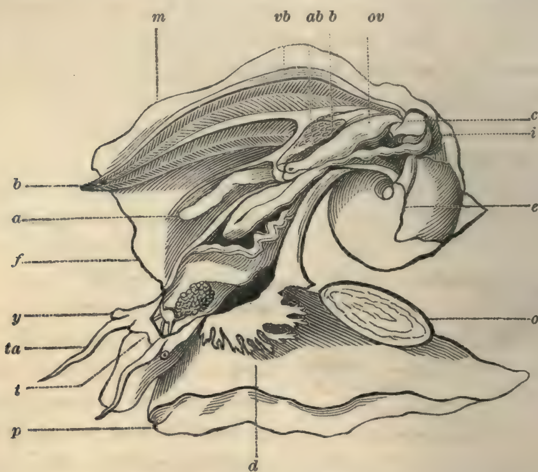


FIG. 555.—ANATOMY OF TURBO PICA: *p*, foot, *o*, operculum; *t*, proboscis; *ta*, tentacula; *y*, eyes; *m*, mantle opened longitudinally, to show the disposition of the respiratory cavity; *f*, anterior border of the mantle, which, in its natural position, covers the back of the animal, leaving a wide slit by which the water enters the branchial cavity; *b*, the gills; *vb*, branchial vein, returning to the heart, *c*; *ab*, branchial artery; *a*, anus; *i*, intestine; *e*, stomach and liver; *ov*, oviduct. On the upper side of the neck are seen the cephalic ganglion, and the salivary glands. And at *d* is shown a fringed membrane, which forms the lower border of the left side of the opening that leads to the respiratory cavities.

lung-like cavity (Fig. 564), is situated on the back of the animal, and is lodged in the last turn of the spiral shell, when the Mollusk is provided with an envelope of this kind. Among those Gasteropods destined to breathe in water, the arrangement of the gills varies considerably; in many, these organs are lodged

in a cavity analogous to that which constitutes the lung of the preceding (Fig. 555); but in others, they are placed between the mantle and the foot, or even on the back of the animal, so as to float freely in the surrounding liquid. As examples of the pulmonic Gasteropods, we may mention the Snail, and the Slug, which live on land; and the Lymnæa, the Planorbis, and others, which live in stagnant waters, and come to the surface to take in the air necessary for their respiration. Among Gasteropods provided with gills inclosed in a dorsal cavity we find the Volutes, Whelks, Cowries, Olives, and many others. The Limpets and Pleurobranchi (Fig. 556) have these organs in the furrow which separates the foot from the mantle; and in the Doris (Fig. 568), the Eolis (Fig. 557), and others, they consist of folds or tufts, sometimes very numerous, fixed to the dorsal surface of the body.

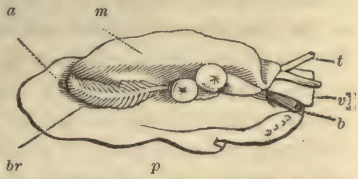


FIG. 556.—PLEUROBRANCHUS: *m*, the mantle turned back to show the gills, *br*: *a*, the anus; *b*, mouth and proboscis; *v*, hood; *t*, tentacula; *p*, foot.

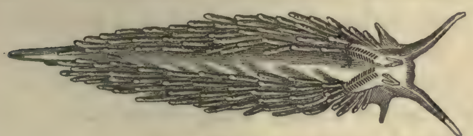


FIG. 557.—EOLIS.

904. The mouth of Gasteropods is surrounded with contractile lips, and is sometimes armed with horny teeth, which occupy the palate. In several other animals of this class, the anterior part of the palate is very fleshy, and can be made to project outwards, so as to form a proboscis. In some cases, the stomach also is provided with cartilaginous, or even calcareous, projections or teeth, fitted to divide the food. The intestine is bent upon itself, and is lodged between the lobes of the liver and ovary: lastly, the anus is situated nearly always on the right side of the body, at but a little distance from the head.

905. In this Class, the organs of sensation are less developed than in the Cephalopods; the tentacula, which most Gasteropods

carry in front, serve but for touch or smell. Their apparatus for hearing, which has been only recently discovered, is very simple; consisting of a little sac on each side, which is almost imbedded in the cephalic ganglion. The eyes, which are sometimes wanting, are very small, and of a very simple structure; sometimes they are situated on the head, and sometimes carried at the base, the side, or the point of the tentacula. The Nervous System is less developed than in the preceding Classes; and is chiefly composed of a cephalic ganglion, which is connected with others, either placed immediately beneath the œsophagus, or scattered in distant parts of the body, according to the position of the organs they respectively supply, which varies considerably in this group. (See ANIM. PHYSIOL. § 438).

906. Of these animals, some are terrestrial, some inhabit fresh waters, but most live in the sea. In general they are formed for crawling, as the Snail, the Whelk, the Limpet, &c.; but sometimes they are rather adapted for swimming, as is the case with many of the naked Gasteropods. A few of this class attach themselves to the surface of rocks, and pass a great part of their lives with little variation in place. This is the case with the Limpet for example; which is frequently found partially imbedded in a hollow exactly fitting to its shell, and therefore evidently formed by its own action. But the attachment of such is not a solid union like that of the Oyster and some other Conchifera; being only produced by the adhesion of the muscular disc, or foot, which, acting like a sucker, can be detached at any time by the will of the animal.

907. As already remarked, the Shells of Gasteropoda, where they exist, are usually formed in one piece, or are *univalve.* There is no instance of a Gasteropod forming a *bivalve* shell, unless we consider the large calcareous operculum of some of these Mollusks in the light of a second valve, with which it cannot be rightly compared. But there is a group, nearly allied to the Limpets, which is distinguished by the possession of a *multivalve* shell (Fig. 584); the valves being disposed like the segments of Articulated animals, and being connected by a complex muscular apparatus, which strongly reminds us of that

which binds together and moves the several segments in that sub-kingdom. The material of which the shell is composed, varies considerably in regard to the relative quantities of animal and of calcareous matter which it includes. In the Cones, Cowries, Olives, and others known as *porcellanous* shells, the quantity of animal matter is so small, that it can with difficulty be detected; but in others, as the Limpet, there is considerably more; and in some instances there is an almost entire absence of calcareous matter, the shell having merely the consistence of horn.—It is remarkable that, notwithstanding so many of this group are destitute of shell in their perfect condition, *all* the species belonging to it possess the rudiments of a shell when they come forth from the egg; and this has nearly the same form in every case, being usually a simple cone, with the point slightly turned over. In most Gasteropods this shell is retained, and is enlarged by successive additions; but it soon falls off in those cases, in which it is not to be permanent. The additions which are made to the shell, for the purpose of deepening its cavity and widening its mouth, sometimes appear to be confined to the edge only; whilst in other instances a new layer is thrown out as a lining to the whole interior of the shell. In the former case the line of junction between the old and the new parts is often marked externally by a prominent rib; but the internal surface is beautifully smoothed off.

908. The forms of the shell in this Class are subject to great variations; but those which appear most widely separated, may be shown to be connected by intermediate links; as well as to have a common origin. The simplest of all shells in point of form, is that of the common Limpet, which is merely a cone, more or less expanded at the base; and in which the successive additions are all made in the same direction. In an allied genus, the *Pileopsis*, we find the point or apex of the cone somewhat prolonged and turned over, so as to resemble a "fool's cap" in its form; and the increase of this tendency produces a regular spiral shell, such as that of the *Planorbis*, in which all the whorls or turns are upon the same plane,—as in a "Catherine's wheel." But if the whorls do not continue in the same plane, but turn

round a central line in a corkscrew-like mode, a shell is formed like that of the common *Snail*, or the *Pleurotoma* (Fig. 582). From forms of this kind, we may return to the *Dentalium*,—which has a long straight cone, like that of the Limpet narrowed and drawn out,—by the *Scalaria* or Wentletrap, in which the coils of the spire touch each other only by their ribs; and by the *Magilus* and *Vermetus* (Fig. 583), in which the commencement only of the shell possesses a spiral form, the remainder being prolonged into a tube which nearly approaches the straight direction. When the whorls revolve around a vertical line, instead of remaining in the same plane, a sort of central pillar is formed, which is termed the *columella*, (Fig. 558); this is usually grooved at its lower part, for the passage of water to the respiratory organs.

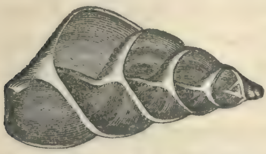


FIG. 558.—SECTION OF ACHATINA COLUMNARIS.

909. The margin of the shell is not unfrequently fringed with spines, as in the *Murex*; these are formed (as are similar appendages in the *Conchifera*,) by prolongations of the Mantle; and the dissimilar number of them in different specimens has caused the establishment of many species, which, now that the habits of the animal are better known, prove to be but varying forms of the same. For it has been ascertained that the animal has not only the power of forming new spines, but of removing

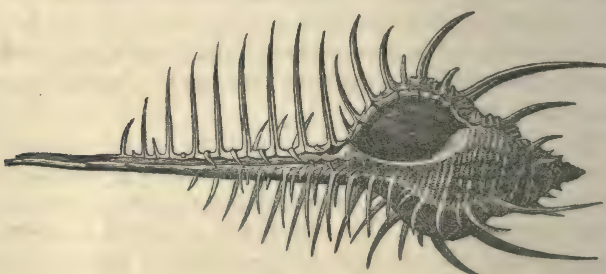


FIG. 559.—MUREX TENUISPINA.

old ones, especially such as would interfere with the continued growth of the shell. The edge of the Mantle is applied against their bases, and a kind of absorption of shelly matter seems to take place, a notch being formed, which causes them to be easily broken off. Various analogous changes are produced by a similar action in other shells, the portions first formed being wholly or partially removed. Sometimes the walls of the older portions are thinned for the purpose of lightening the shell; and in other cases the top of the cone is altogether removed, a groove having been formed around its interior, which renders it so weak as to be easily broken off; in these last cases, the animal previously withdraws itself from the part that is thus to be separated, and throws a new partition across, by which the top of the shell remains closed after the division. A shell thus deprived of its apex is said to be *decollated.*

910. It is not only by such removals, that the form of univalve shells undergoes a great change. Sometimes additions are

FIG. 560.—PTEROCERAS SCORPIO: *a* and *b*, back and front views of the young shell; *c* and *d*, the same of the adult.

made to them, which completely alter their figure, so that two individuals of different ages would be scarcely supposed at first

sight to belong to the same tribe. But in all these cases, the form of the young shell may be traced in that of the adult. The accompanying figures of the *Pteroceras* show this change in a moderate degree; in other genera it is much more remarkable. In another group of shells, of which the common *Cowry* is an example, a still more curious alteration takes place. In the young shell the edge is sharp, and the mouth an opening of considerable breadth. This state continues as long as the shell is increasing in size; but when it has arrived at adult age, the outer

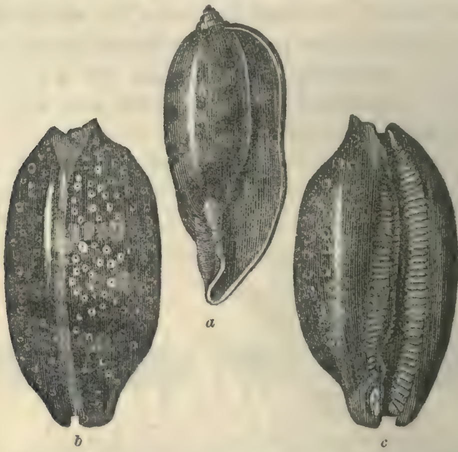


FIG. 561.—CYPRÆA EXANTHEMA: *a*, young shell; *b* and *c*, back and front views of adult shell.

lip is thickened, and brought so near the other as to leave but a narrow chink between them. At the same time, a prolongation of the mantle on each side deposits a new layer of shelly matter on the outside of the previous one; and as the two prolongations meet along the back, (the line of their junction being usually evident on the shell), this additional coat, which is very hard and *porcellanous* in its texture, incloses the whole previous shell.—The *operculum* is principally confined to the aquatic Gasteropoda. It is sometimes of the same texture as the shell itself, and sometimes horny. It does not always close the entire

mouth of the shell; but it is sometimes made to fit it, at all stages of growth, with the most beautiful accuracy. Some of the land species also possess an operculum; but in general they are destitute of it, and they form during hybernation a temporary closure to the mouth of the shell, by a viscid secretion, which hardens into a thin plate, and includes within it a bubble of air. Behind this, a second and even a third similar partition is occasionally found, as in the common Snail.

911. The subdivision of this extensive Class into Orders, may be best effected by arranging the different tribes according to the character and position of the respiratory organs. The following are those adopted by Cuvier:—

I. Pulmonea. These are for the most part terrestrial species, adapted to breathe the air by means of a pulmonary sac, or air cavity, the orifice of which they can open or close at will. Many have no shell.

II. Nudibranchiata. These, as well as all the succeeding Orders, are aquatic, being adapted to respire water by gills, like other Mollusca. The animals of this Order have no shell; and they carry their branchiæ, which present various forms, on some part of the back.

III. Inferobranchiata. These are similar in many respects to the preceding, but the branchiæ are situated under the margins of the mantle.

IV. Tectibranchiata. In the greater part of the animals contained in this Order, the branchiæ are situated upon the back or on the side, and are covered in by a fold of the mantle, and this fold usually includes a shell more or less developed.

V. Pectinibranchiata. The animals of this Order, to which belong all the spiral-shells, except those of the Pulmonea, are so named from the comb-like form of the gills, which are usually situated in a cavity behind the head; corresponding with the respiratory sac of the Pulmonea. This is by far the most numerous Order of the whole.

VI. Tubulibranchiata. These have many affinities with the last Order, but the shell is spiral only at its apex, where it is commonly fixed to (or rather inclosed by) other bodies, and is prolonged in the shape of a tube more or less regular.

VII. Scutibranchiata. In these, also, there is a considerable resemblance to the Pectinibranchiata in the form and position of the gills ; but the shells are very open, scarcely in any degree spiral, and cover the body and gills like a shield ; and they also differ essentially in their mode of reproduction.

VIII. Cyclobranchiata. These Mollusks have their gills disposed in little tufts under the margins of the mantle, much as in the Inferobranchiata ; but they have shells, which are spread out over the body, and differ from that Order in their mode of reproduction.

Order I.—PULMONEA.

912. Although the greater part of the Mollusks of this Order live on land, some are aquatic ; but these, like the aquatic

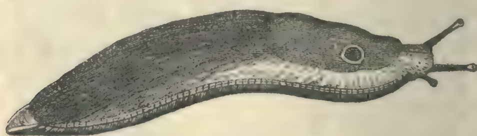


Fig. 562.—Limax rufus.

air-breathing Insects and Vertebrata, are obliged to come occasionally to the surface to breathe. They all feed upon vegetables, and many of them do so exclusively ; but some are extremely voracious, and will devour almost any organised matter that falls in their way. They are diffused through all climates, particular species being restricted to each. Those without a shell, commonly known as slugs, constitute the family Limacinæ. In the common *Slugs*, as in most of the terrestrial species of this Order, we observe a prominent head, with four tentacula ; and at the end of the longer pair the eyes are situated. These tentacula can be drawn inwards, by a process resembling the inversion of the finger of a glove. On the back there is a kind of shield or disk, formed by the mantle, which sometimes incloses a small shell. This shield covers the pulmonary sac, the opening of which is on its right side, and the head can be withdrawn

beneath it. The *Testacella* is a kind of slug which has the disc of the mantle at the posterior extremity, and this always con-

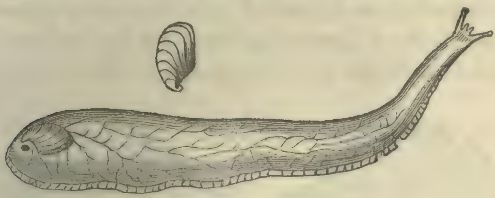


FIG. 563.—TESTACELLA.

tains a small shell. This animal, which feeds largely on earth-worms, is abundant in the south of France, and has lately been introduced into the gardens of this country, where it is multiplying rapidly.

913. The *Snails* and their allies, constituting the family HELICINÆ, are closely allied to the Slugs in organisation ; differing in but little else than the possession of a shell, into which the body may be withdrawn. The Common Garden-Snail of this country, and the *Helix pomatia*, or Edible Snail of France and Italy, are well-known examples of this family. More striking ones are to be found, however, in tropical climates. Among the members of this group, we may especially notice the genus *Anastoma*, which is distinguished by the peculiar form and position of the mouth of the shell in the adult. During its early life, its mouth is in the same position as that of other snails ;

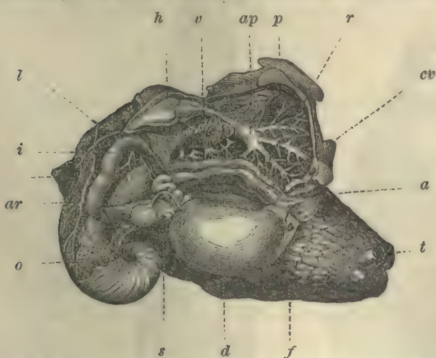


FIG. 564.—ANATOMY OF SNAIL ; *f*, foot ; *t*, tentacula half contracted ; *d*, a sort of diaphragm, separating the respiratory cavity from the other viscera ; *s*, portion of the stomach ; *l*, liver ; *o*, ovary ; *i*, intestine ; *r*, rectum, or last part of the intestine ; *a*, anus ; *h*, heart ; *ap*, pulmonary artery, distributed over the walls of the pulmonary cavity, *p* ; *ar*, aorta ; *v*, secreting gland for the mucus which covers the body ; *cv*, its excretory duct, opening near the anus.

and thus it continues until the shell is increased for the last time. The direction of the curve is then entirely changed ; a mouth with thickened lips and projecting teeth is formed, so as to be on the same plane with the spire ; and from henceforth it must crawl with the spire downwards, unlike all other snails.

FIG. 565.—ANASTOMA GLOBOSA.

Some species of the genus *Bulimus* attain to great size, the eggs being as large as those of a pigeon. In certain species of the latter genus, the direction of the coils of the shell is opposite to what it

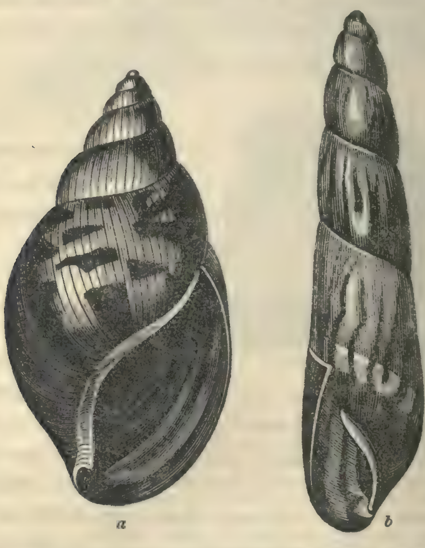


FIG. 566.—*a*, ACHATINA ZEBRA ; *b*, ACHATINA VIRGINEA, (a reversed species).

is in other spiral shells ; such are said to be *reversed*. A European

species is one of those most remarkable for the decollation of its shell. Another large snail of tropical climates, as *Achatina*, which feeds on trees and shrubs, chiefly on the western coast of Africa, and in the West Indies; several of its species are distinguished by the beauty of their colours; and some of them are reversed.

914. The aquatic Pulmonea have only two tentacula. From the necessity of coming to the surface to breathe, they can only live in water of inconsiderable depth; and they chiefly inhabit ponds and shallow streams, or the banks of rivers. Some, however, live on the sea-shore. The *Planorbis*, the shell of which is quite flat, having all its coils upon the same level, is a very common genus in this country; as is also the *Lymnæa*, which feeds upon seeds, as well as the softer parts of the plants, and the stomach of which has a very muscular gizzard.

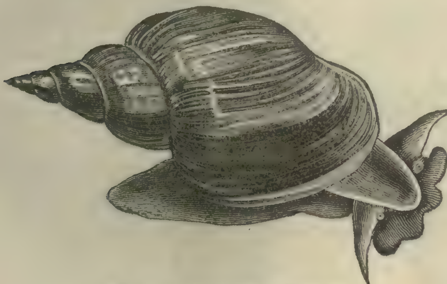


FIG. 567.—LYMNÆA STAGNALIS.

ORDER II.—NUDIBRANCHIATA.

915. The animals of this Order, which might be designated *Sea-Slugs*, are all marine; and being adapted to breathe water at any depths, and also (in many instances) to swim with facility, they are often found at a great distance from land. When they swim, it is usually in a reversed position, the foot being turned upwards; this is made concave by muscular action, so as to serve as a kind of boat, the buoyancy of which keeps the animal at the surface without effort. This Order is a very numerous one; and some of its species attain considerable size. The number of those existing on our own shores is much greater than has been usually supposed; a large number of species

having been discovered by late researches. The position of the gills varies in different genera. Thus in the *Doris* (Fig. 568),

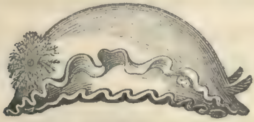


FIG. 568.—DORIS CORNUTA.

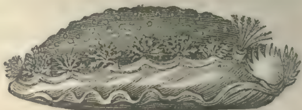


FIG. 569.—TRITONIA.

they are arranged in a circular form around the termination of the intestine. In the *Tritonia* (Fig. 569) they are placed in

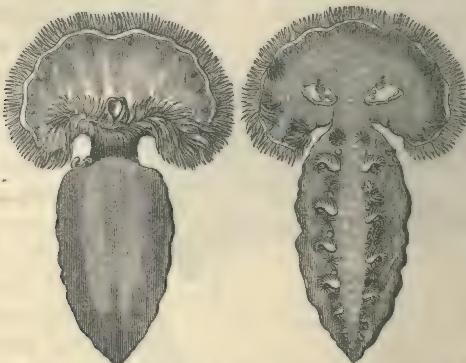


FIG. 570.—THETYS LEPORINA, UPPER AND UNDER SIDE.

tufts on each side of the back. In the *Thetys* (Fig. 570), also, they are arranged in two rows along the back; this animal is remarkable for the large membranous fringed hood, which covers the head. In the *Glaucus* (Fig. 571) they form two or three large tufts on each side, which give assistance in swimming. These beautiful little Mollusks are inhabitants of the Mediterranean and Indian Oceans; their hues are azure blue and silver; and they swim with great rapidity on their backs.

FIG. 571.—GLAUCUS FORSTERI.

In the *Eolis* (Fig. 557), the act of respiration appears to be performed by means of numerous finger-like processes, with which the back is covered.—Most of these animals deposit their eggs on the shore in gelatinous masses; the eggs being very regularly arranged in rows or bands. Of the immense number of eggs which some of these contain, an idea may be derived from the following fact, which is mentioned by Mr. Darwin, in regard to the mass deposited by a large white species about 3½ inches long, on the shores of the Falkland Islands. From two to five eggs (each of them 3-1000ths of an inch in diameter) were contained in a little spherical case. These cases were arranged two deep in rows; and these rows adhered to each other in such a manner as to form a ribbon,—running across it from one edge to the other. One of these ribbons measured twenty inches in length, and half an inch in breadth; and by counting the number of the spherical cases contained in one-tenth of an inch of each row, and the number of rows in an equal length of the ribbon, Mr. D. ascertained that there must have been, in the whole mass, at least six hundred thousand eggs.

Order III.—INFEROBRANCHIATA.

916. The small number of Mollusks contained in this Order differ but little from the last, except in the position of their gills, and their incapability of swimming. They are, therefore, confined to the sea-shore; where they subsist (as do also the Nudibranchiata) upon sea-weeds and other aquatic plants.

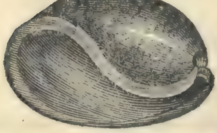
Order IV.—TECTIBRANCHIATA.

917. This Order begins to show an approach to that arrangement of the gills, which characterises the great bulk of the Class; these organs being concealed beneath a fold of the mantle, in which a small shell is usually contained. The animals composing it are all marine; and live chiefly on the

shore, or on floating sea-weeds. A very characteristic example of the group is the *Aplysia*, commonly termed Sea-Hare, which

FIG. 572.—APLYSIA.

is abundant on many parts of our own coasts. Its common name is probably derived from the peculiar form of the superior pair of tentacula, which are flattened and hollowed like the ears of a quadruped. The head has a very distinct neck. The gills consist of leaflets arranged in a complex form, and situated on the back beneath a fold of the mantle, which also incloses a flat horny shell (Fig. 572). The digestive apparatus is very complicated ; consisting of a membranous crop like that of Birds, a gizzard having cartilaginous walls, and a third stomach beset with sharp hooks in its interior. These animals feed on seaweed. They are very sluggish in their movements, but have a peculiar means of defence,—consisting of a deep purple liquid (said by some to have acrid properties), which they can discharge from the edge of the mantle when alarmed, and by which the surrounding water is discoloured, so that the animal cannot be discerned. Nearly allied to the Aplysia are the *Bulla* and



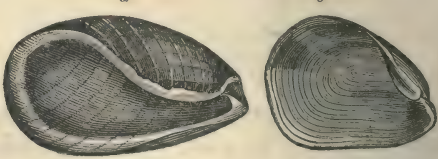


FIG. 573.—BULLÆA APERTA. FIG. 574.—BULLA LIGNARIA (*a*) ; BULLA AMPULLA (*b*).

Bullæa ; these have a small calcareous shell, in which the spiral

form begins to manifest itself. The *Bullæa aperta* (Fig. 573) is found in almost every sea, living on oozy bottoms. The *Bulla lignaria* (Fig. 574, *a*) is remarkable for the density of the walls of the stomach; amidst the tendinous fibres of which, a large quantity of calcareous matter is deposited, forming plates of bony firmness; these are moved against each other by powerful muscles, so as to rub down almost any substance that is placed between them. The Author has more than once found a small bivalve shell in this situation. The shell of the *Bulla ampulla* (Fig. 574, *b*) is interesting as exhibiting, in its flat open form, a transition towards that of the Aplysia.—To this group is also referred the curious *Bursatella* (Fig. 575), which is an inhabitant of the Indian seas. Its gills project far beyond the opening of the mantle.

FIG. 575.—BURSATELLA LEACHII.

ORDER V.—PECTINIBRANCHIATA.

918. This Order is not only by far the most numerous in the whole class, but contains the animals which may be regarded as its most characteristic examples. They have all two tentacula, and two eyes; the latter being sometimes mounted on a footstalk, as in the Snail. The mouth is prolonged into a sort of proboscis; and the tongue is furnished with little hooks, or recurved spines, which enable it to wear down the hardest bodies by slow and oft-repeated action. The cavity, in which the gills

are fixed, occupies the last whorl, or turn, of the shell (§ 903); and in some of the Order there is a tubular prolongation of the mantle, termed the *siphon*, for the purpose of conveying water into this cavity, so that the animal can respire without putting forth its body from its shelter. By the presence or absence of this organ, and by the form of the shell (which here appears to bear a sufficiently constant relation with that of the animal), this large group may be arranged under the following families :—

I. TROCHOIDÆ, or the *Periwinkle* tribe, in which there is no siphon, and which have the mouth closed by an operculum, usually calcareous.

II. CAPULOIDÆ, which have a wide open shell, very much like that of the Limpets, without an operculum, and destitute of a notch at the margin for the passage of the siphon.

III. BUCCINOIDÆ, or the *Whelk* tribe, which have a spiral shell, and a canal at the end of the columella for the passage of the siphon.

919. The family TROCHOIDÆ is a very extensive one, and includes numerous species which are interesting on account of their peculiar habits, as well as for the beauty of their shells. In the genera *Trochus* and *Turbo*, which may be considered its *types*, the interior of the shell is nacreous; and the exterior, when cleaned, usually presents a very pleasing mixture of colours. The shell, though spirally coiled, usually has a more or less regular conical form (as is seen in the common Periwinkle);—the first, or earliest whorl, forming the point of the cone, and each whorl extending a little beyond the one above it, so as to increase the diameter of the shell very regularly;—and the mouth being situated at the base of the cone, which in the Trochus is almost flat. The *Trochus* is distributed all over the world; and at least seventy species of it are known, the largest being restricted to tropical climates. Among these we may especially notice the *Trochus agglutinans*, a native of the West Indies, which derives its name from its singular habit of glueing to its shell small pieces of stone, coral, shell, &c. This seems to answer the purpose of strengthening its shell, which is thin and brittle. A fresh-water species from Brazil has been described, in which

there did not appear to be any real shell at all ; the animal being inclosed in cases made up of little stones and grains of sand, agglutinated together with such exactness, as to form the *fac-simile* of a real Trochoid shell. The *Trochus longispina* from India has the circumference ornamented with a row of long spines, of a silvery or gold colour, placed at regular distances. In the *Turbo*, to which the common Periwinkle belongs,* the mouth of the shell is quite round ; and it is in this genus that we find the most massive and stony opercula. The Periwinkle is very generally used as an article of food in the neighbourhoods in which it abounds. It is considered in Sweden to afford a sign of the coming weather ; the peasants having observed that, whenever the Periwinkles ascend the rocks, it is a sure sign of a storm being near, their instinct having taught them to place themselves out of the reach of the dashing of the waves ; when, on the contrary, they make a descent upon the sand, it is an indication of a calm. The number of known recent species is between thirty and forty; and, as in the former case, those of temperate climates are much surpassed in size by the inhabitants of tropical seas. Allied to the Turbo is the *Scalaria*, in which the turns of the spire come in contact with each other only by their ribs, and of which the principal species—the *Scalaria preciosa*, or Wentletrap—was long famous on account of the high price given for it by shell-collectors.

920. The preceding genera are all inhabitants of salt water only ; and their shells, as well as their bodies, have a very characteristic and peculiar structure. We have now to advert to some, in which there is a considerable resemblance, in one or both of these particulars, to the Helices and their allies. First among them may be mentioned the *Paludina*, which nearly approaches the Turbo in the form of its shell, but is an inhabitant of fresh water ; it possesses, however, the rudiments of a siphon, for the introduction of water into the respiratory cavity. In the common species, *Paludina vivipara* (Fig. 576), the young are produced alive, the eggs being hatched within the oviduct. The *Ianthina*, or Violet Snail, is a beautiful little Mollusk, having a delicate

* This is referred by most Naturalists to a new genus, *Littorina*.

fragile violet-coloured shell, which presents the general form of that of the Helix, although differing from it in some important particulars. This shell has no operculum; but this appendage is replaced by a curious apparatus, which serves as a float, enabling it to swim at the surface of the sea without any effort. To the foot are attached a number of vesicles, full of air, and resembling foam-bubbles; and the animal seems to have the power of compressing or emptying these at will, so as cause itself to sink.

FIG. 576.—SHELL OF PALUDINA.

When irritated or alarmed, it pours out a violet-coloured secretion, resembling its shell in colour, which darkens the water around it, and thus serves for its concealment, in the manner of the ink of the Cuttle-fish. The genus *Nerita*, which is nearly allied to this, contains several species which inhabit fresh water; and some which even live out of the water altogether,—by the aid, probably, of some provision analogous to that which enables the Climbing Perch, or the Land Crab, to live at a distance from the water. The *Ampullaria* (Fig. 577), has a shell still more like that of the Helices; and although provided with a branchial comb, like that of the Trochoidæ in general, it has also the rudiment of a pulmonary sac, like that of the Snails, which is said to be filled with water, and thus to keep the gills moist for a long time. The animal inhabits the fresh or brackish waters of warm climates, and forms a calcareous operculum. It is remarkably tenacious of life, partly in consequence of the curious provision just alluded to. Thus specimens have been brought from Egypt to Paris alive, although packed up in sawdust; and in one instance, a box containing a large number of river-shells from the Nile having been delayed four months on the road, the Ampullariæ were found to have remained alive

FIG. 577.—AMPULLARIA RUGOSA.

in the midst of the mass of putrefaction caused by the death of the other animals. The *Helicina*, which is nearly allied to this, is, like the *Helix*, a terrestrial Mollusk.

921. The family CAPULOIDÆ is a small one, containing only a few genera, which have shells more or less closely resembling that of the Limpet, but which must be placed among the Pectinibranchiata, on account of the structure and position of their respiratory organs. There is nothing in their history sufficiently remarkable to detain us.

922. The family BUCCINOIDÆ is a very extensive one, and contains a large proportion of the shells which make the greatest display in Conchological museums. They are all distinguished by the notch at the extremity of the columella for the passage of the siphon; and the greater or less length of this canal serves to distinguish the different subdivisions. Thus in the *Cones*, *Cowries*, &c. (Figs. 578, 579), it is very short; in the *Buccinum*, or Whelk, (Fig. 580), however, the canal is longer; whilst in the Murex (Fig. 559), and its allies, the canal is very much prolonged. The *Cones*, which are so named from the conical figure of their shells, are remarkable for the length and narrowness of the mouth, and for the consequent thinness and breadth of the head and neck of the animal. The shells of this genus are in general very beautifully coloured; and their markings possess a peculiar clearness and definiteness. Some of the species are so highly valued by Collectors, as to bring a higher price than almost any other shell—as much as three hundred guineas having been given for a single specimen. The Cones are found abundantly on the shores of all tropical countries, particularly of Asia; but they become more rare as they approach the northern hemisphere; and a few species only are found in the

FIG. 578.—CONUS GENERALIS.

Mediterranean. The *Cypræa*, or Cowry, is also remarkable for the brilliancy of its colours, and for the high polish of which it is susceptible. The shells of this genus and its allies are pre-eminently *porcellanous ;* that is to say, they have much of the half glassy appearance of porcelain when they are polished ; and they break with a fracture similar to that of earthenware. This results in part from the very small quantity of animal matter they contain. The form of the shell in the young *Cypræa* is not very unlike that of the Cone ; its edge being thin and sharp ; but it subsequently undergoes a very remarkable change, as already described (§ 910) ; and it is then only that the full beauty is acquired by the shell, as it depends on the deposit of the final layer of shelly matter over the whole exterior. The genus *Cypræa*, also, is almost restricted to warm climates ; where its species are very abundant. The *Cypræa moneta*, or Money Cowry, is the current coin of the natives of Siam, Bengal, and many parts of Africa ; it is collected in the latter by the negro women, and is sent thence to distant countries. In Bengal, 3200 of these shells are reckoned to be equivalent to a rupee, or about two shillings of English money. In the Friendly Islands, permission to wear the *Cypræa aurantia*, or Orange Cowrie, as an ornament, is only granted to persons of the highest rank. The *Cypræa aurora*, which is considered the most rare species of the entire genus, is suspended by the New Zealanders to their dress as an ornament.—Nearly allied to the Cone and Cypræa, are the *Ovula*, *Oliva*, and many other genera.

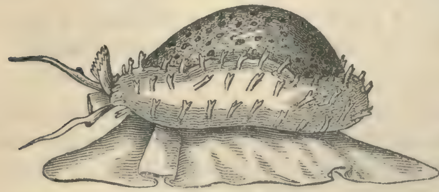


FIG. 579.—CYPRÆA.

923. The *Buccinum* and its allies have the columella somewhat prolonged, and exhibit a considerable notch or furrow for the siphon, which is bent towards the left. The genus Buccinum probably contains the largest number of species, and these the most universally diffused, of any Pectinibranchiate Gastero-

pods. The shells are found in all parts of the world, from the Polar circles to the Equator; and the animals of many species are used as food,—those of the *Buccinum undatum* of our own shores being known as Whelks. The shells are not remarkable for brilliant colours; but they present many interesting varieties of form and marking. The animals never attain a large size; and the greater number of them frequent the shore. Their habits are analogous to those of a large proportion of this group, to which, therefore, a similar description will apply. They obtain their food by means of a long proboscis, inclosing a tongue that is furnished with sharp teeth at its extremity; by means of which they bore into other shells, and extract the animal from the interior. This proboscis is not merely adapted, like that of the Elephant, to bend itself in all directions; but it may be entirely retracted into the body, by means of a complex muscular apparatus, which completely draws back the point, and the half of the proboscis nearest to it, into the half attached to the head;—just as when the finger of a glove is pushed back into the part that incloses the palm. When the proboscis is extended, the tongue is protruded, and by the file-like action of its teeth, even the hardest shells are worn away. These carnivorous Mollusks are not restricted in their destructive operations by any ties of kindred; for the shell of the Whelk itself is not unfrequently found perforated, just as if by one of its own species.

FIG. 580.—BUCCINUM UNDATUM.

924. Nearly allied to the Buccinum is the *Cassis*, or Helmet-shell, which is one of the largest of the whole Class. Most of the species are inhabitants of tropical shores; but a few are

found on the coast of the Mediterranean. They live at some distance from the shore, on the sand, into which they occasionally burrow, so as to hide themselves. The shells of the *Cassis rufa* and other species are beautifully sculptured by Italian artists, in imitation of

FIG. 581.—CASSIS TUBEROSA.

antique *cameos;* the different layers of colouring matter which they contain, strongly resembling in hue those of the onyx and other precious stones formerly used for this purpose. Of these, a great variety of ornaments are made; and of late years a considerable trade has been carried on in them on the Continent. —Numerous other genera may be associated in the same group; but it will be sufficient here to notice the *Purpura*, a shell of comparatively small size, but which is very abundant in some situations on our own coast and elsewhere. The total number of known species exceeds fifty; the largest among them are inhabitants of tropical seas. It was from the animals of this genus that the Roman purple dye was obtained; and a small quantity of this may be found in the *Purpura lapillus* of the British coasts.—All the Mollusks of this group, so far as is at present known, have the habit of depositing their eggs in egg-cases, or *nidamenta;* which are of various forms in the different species, and are attached in different modes. That of the Buccinum is often to be met with on our shores, in the form of a large irregular ball, composed of a number of little vesicles attached together, each containing several eggs. The Purpura forms a large number of distinct cylindrical cases, which it attaches to the rocks it infests.

925. The last group comprised in this extensive family is

that of the *Murex* and its allies, which are distinguished by the great length of the siphon, as well as (in many instances) by the remarkable prolongation of the shelly canal in which it is protected along a part of its course. This is nowhere more remarkable than in the Murex itself (Fig. 559). Frequently, however, the shelly canal is not itself prolonged ; as is the case in the *Pteroceras* (Fig. 560). To this group belong a considerable number of large shells. The ***Fusus*** much resembles the Murex ; but has none of those ridges or *varices*, which mark, in the latter, the lines of successive addition to the shell.—In like manner, the *Strombus* is allied to the Pteroceras ; being distinguished, like it, by a great extension of the lip, when adult age is reached ; but this lip is destitute of the long finger-like processes, which are so remarkable in that shell. The accompanying figure of the *Pleurotoma*, another genus belonging to the same group, is here introduced for the purpose of explaining the names which are given by Conchologists to different parts of a shell, and which are made use of in the scientific description of it. At *a* is seen the *canal* for the passage of the siphon ; *b*, a hollow, here nearly closed up, termed the *umbilicus ; c*, the *internal edge* or *left lip*, which is partly formed by the columella ; *d*, the *external* or *right lip*, the edge of which is free ; *e*, the *notch* or slit, which is peculiar to this genus ; *f*, the sinus ; *g*, part of the last turn of the spire, which is called the *venter* or belly ; *h*, *h*, the turns or *whorls* of the spire ; *i*, the *sutures*, or lines of union between these.

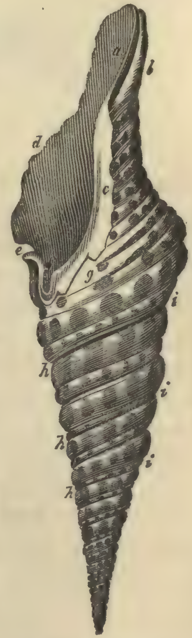


FIG. 582.—PLEUROTOMA BABYLONICA.

Order VI.—TUBULIBRANCHIATA.

926. The Mollusks of this Order construct an irregularly tubular shell; which so much resembles that formed by certain Annelida, as to be scarcely distinguishable from it. They are very few in number. The *Vermetus* (Fig. 583) is the principal genus of the group. This is remarkable for the close resemblance

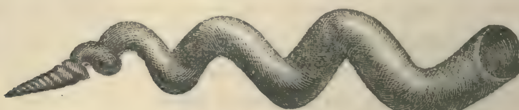


Fig. 583.—Vermetus.

of its shell to that of the Serpula (Fig. 528); but, when perfect, it may be generally distinguished by the regularly-spiral twisting of its first-formed portion. Some species associate together in large masses, so as even to form reefs; whilst others attach themselves to Coral, and lengthen their shells in proportion as the Coral grows up around them. When the animal has quitted the lower part of its tube, that it may keep itself at the surface, it usually throws a partition across, in the manner of the Nautilus; and a tolerably regular series of such partitions is not unfrequently found. In the *Magilus*, an allied genus of similar habits, whose tube is sometimes lengthened in this manner to as much as three feet, the first-formed part of the shell, instead of being cut off, is sometimes completely filled up by the exudation of solid matter.

Order VII.—SCUTIBRANCHIATA.

927. This Order is also a small one, containing but two principal genera, which do not differ widely from the Limpets, except in the disposition of the gills. The shells are very open, without an operculum, and the greater number are not in any degree

spiral. In the *Haliotis*, the shell is slightly twisted; and from a faint resemblance it is thought to bear to the ear of a quadruped, it has been called the Sea Ear. This animal, in its living state, is one of the most beautiful of Gasteropods, on account of the variety and richness of its colours. Its shell, when the surface is polished, possesses a pearly lustre, with resplendent metallic hues. It is consequently much sought for as an ornament. The animal attaches itself to the rock, after the manner of a Limpet, by a large muscular foot; and the extent of the adhering surface is so great, that a very considerable force is required to detach it, when the animal is putting forth its strength. The best mode of obtaining the shell, is to place the hand or some instrument under its edge (which is usually a little separated from the rock when the animal is undisturbed); and to endeavour to remove it before the animal is alarmed. When this attempt is not successful, the animal draws its shell down upon the rock with such firmness, as to grasp most securely anything that is under its edge; and in this manner fatal accidents have occurred to men, who have incautiously attempted to remove these shells, when under water.

Order VIII.—CYCLOBRANCHIATA.

928. The general form of the *Limpets*, which principally compose this Order, is well known; and the peculiarity in the position of their gills has already been mentioned. Closely allied to the Limpets in general structure, but differing remarkably in the formation of the shell, are the *Chitons*; of which some small species inhabit our shores, but which attain to much greater size between the tropics. Their shell (Fig. 584) is composed of a number of plates arranged behind one another with great regularity, and connected by a very complex series of ligaments and muscles, which reminds the Naturalist of those which unite and move the different segments in the Articulated animals. The Limpets and Chitons fix themselves to the rock, in the same manner as the Haliotis; and it is stated that Crows and other birds,

which endeavour to detach them for food, are sometimes caught by the points of their bills, and are held there until they are drowned by the advancing tide. The Limpets are herbivorous, feeding upon sea-weeds, which they reduce with their long riband-shaped rasp-like tongues. Although we usually see them attached quite motionless to rocks, this is because exposure to the air is unfavourable to their movement, since too free an admission of it between their gills would dry them up. It is when covered with water, that their activity manifests itself.—In many points of structure, the animals of this Order approach those of Bivalve shells. The rock, in the Limpet, may almost be regarded as a second valve; since the muscle takes a firm attachment to its surface, and draws down the shell upon it, in the same manner as the adductor muscle of the Bivalves enables the animal to inclose itself by drawing the two valves of the shell together (§ 932). Moreover the eyes are very imperfect or entirely absent; and many other points of internal structure prove the inferiority of these animals to the Gasteropods in general.

FIG. 584.—CHITON.

929. To enter into any detailed account of the Fossil Remains of this class, would be unsuitable to our present purpose; and it will be sufficient here to state some general facts in regard to them. Remains of Univalve shells, of such a form and structure as evidently to have belonged to Gasteropod Mollusks, are found in nearly every bed formed by the action of water, from the very earliest of those containing fossils of any kind, down to the present time. In many instances, the fossil shells, even of the most ancient beds, may be referred to *genera* which still exist;—thus a species of *Buccinum* is found in the rocks of the Silurian system;—although they do not correspond with any *species* now living, except in cases where there is reason to believe that the deposit was formed at a comparatively recent period.

The Conchologist is generally able to determine, by an examination of the shell, whether it was formed by a *marine* or a *fresh-water* Mollusk; and in this manner he often receives important guidance, in determining the circumstances under which a particular deposit was formed. But he cannot be *sure* in regard to this, from the examination of one or two shells only; since there are many genera, which contain species of both kinds. He is guided, therefore, by the comparison of *all* the shells contained in the deposit, with their nearest allies amongst those now existing. Sometimes there is such a mixture of marine and fresh-water shells, as to induce the belief, that the deposit was formed in the estuary at the mouth of a river, of which both might be inhabitants at once. In other cases, the shells are so exclusively fresh-water, as to indicate that the deposit was formed at the bottom of a river or lake; and in this case, as might have been expected, it is usually of no great extent. When the nature of the shells indicates a deposit from the bottom of the sea, the same shells are frequently found in strata, which differ greatly in their mineral materials, and which present themselves at very different parts of the earth's surface; and they thus afford important assistance to the Geologist, in determining the real correspondence between these deposits. It is a curious fact, that in all the earlier rocks, down to the chalk-formation, the remains of the *carnivorous* Gasteropods bear a very small proportion to those of the *herbivorous* group; and their place would seem to have been then supplied by the numerous Cephalopods of predaceous habits, which then infested the seas (§ 896). Nearly all of these disappeared after the Chalk was formed; and the proportion of the carnivorous Gasteropods exhibits a remarkable increase from that period.

CHAPTER XVIII.

OF THE LAMELLIBRANCHIATE CONCHIFERA.

930. THIS group is nearly synonymous with that of *Bivalves* in the Linnæan arrangement, since all the animals which construct bivalve shells belong to it; but it also contains a few species whose shells are *Incottivalve ;* and some others, in which there appears at first sight an entire departure from the usual form. The Mollusks belonging to this Class are, in common with the Tunicata, destitute of a head; that is, the mouth is not situated upon a prominent part of the body, nor assisted in its choice of food by organs of special sensation in its neighbourhood; but the entrance to the stomach is buried between the folds of the mantle.

931. The part of the structure of these animals which is best known, is the *shell.* This is composed of particles of carbonate of lime, exuded from the surface of the mantle, and contained in the cavities of cells, or between layers of membrane (§ 870). If one of the valves of an Oyster be examined, it will be seen to consist of a number of layers, of which the external one is the smallest, each inner one projecting beyond the one which covers it. This is the case with other Bivalves; but it is more evident in such shells as that of the Oyster, in which the layers adhere loosely together, than in others in which they are more compact. The shelly matter is thrown out at intervals from the surface of the mantle; and as the animal enlarges at each interval, the new layer extends beyond the old one. In this manner a constant relation is preserved between the size of the animal and that of its shell; and the addition of the newly-formed portions, not to the edge only, but to the interior of the whole previous shell, strengthens the latter in proportion to its increase in size.

932. The valves are connected together in various ways.

In the first place, they are jointed by a *hinge*, which is in some instances so firm and complicated, that it holds them together when all the soft parts have been removed. This hinge is sometimes formed by the locking of a continuous ridge on one valve into a groove in the other, and sometimes by a number of little projections or *teeth*, which fit into corresponding hollows in the opposite valve. In the neighbourhood of the hinge (sometimes outside, sometimes inside, or both), is fixed the *ligament;* which is composed of an elastic animal substance; this answers the purpose of binding the valves together, and at the same time of keeping them a little apart, which may be regarded as their natural position. When the animal wishes to draw the valves closely together, it does so by means of the *adductor* muscle, which is fixed to the interior of both valves at

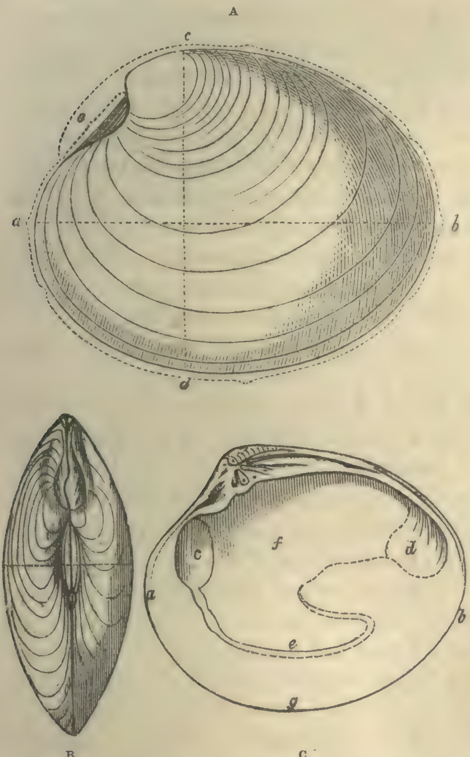


FIG. 585.—A, *a*, *b*, length of the shell; *c*, *d*, height; *e*, lunula, above which is the summit; *d*, the ventral or inferior edge.
B, the line across marks the thickness of bivalves.
C, *a*, anterior extremity; *b*, posterior; *c*, *d*, muscular impressions; *e*, *f*, palleal impression; *g*, lower edge of the left valve.

some distance from the hinge, and of which the insertion can be easily traced by a somewhat rough depression or pit, on the interior surface of each valve. In some Conchifera, this muscle is single, and in others it is double, the two parts being even at opposite ends of the valve (Fig. 585, c). Upon this character it has been proposed to found the primary division of the Class into Orders; but the classification thus formed is not a natural one, inasmuch as it brings together kinds which have little resemblance, and widely separates others which are closely allied.—In Fig. 585 are shown the several parts of a Bivalve Shell, with the explanation of the names by which they are described.

933. In order to describe the general structure of the Lamellibranchiata, it will be advantageous to select some particular illustration; and the *Mactra* (Fig. 586) is well adapted to this purpose. On opening such a shell, it is seen that the two valves are lined by a membrane, in which the animal is enclosed, like a book between the boards of its cover. This membrane is divided into two halves along a considerable part of the edge of the valves; but is united near the large end. In some Conchifera, as will be presently noticed, the two valves of the mantle are separated along their whole extent; whilst in others they are completely closed, with the exception of the two orifices for the ingress and egress of water; which are sometimes drawn out into long tubes. In the Mactra, the water enters through one of the short respiratory tubes, and passes out by the other; but the water thus introduced is principally for the supply of the gills,—the mouth, or entrance to the stomach, being placed at the other end of the shell, where the mantle is quite open; and being thus able to take in food from the surrounding water, which comes into free contact with it. The gills in all Lamellibranchiata consist of four riband-like fringes, fixed to the mantle along the edge of the shell most distant from the hinge. Near the middle of the shell is seen the stomach, with the short tube leading to it, the orifice of which (or mouth) is furnished with four tentacula or feelers. To the left of this is seen the long and complicated intestinal tube, with the liver lying in separate masses amongst its folds. Below this is seen the ovarium, in which the eggs are

formed; this occupies a large part of the cavity of the shell during the breeding season. Close to this is the posterior adductor muscle; by which, with the aid of the anterior muscle

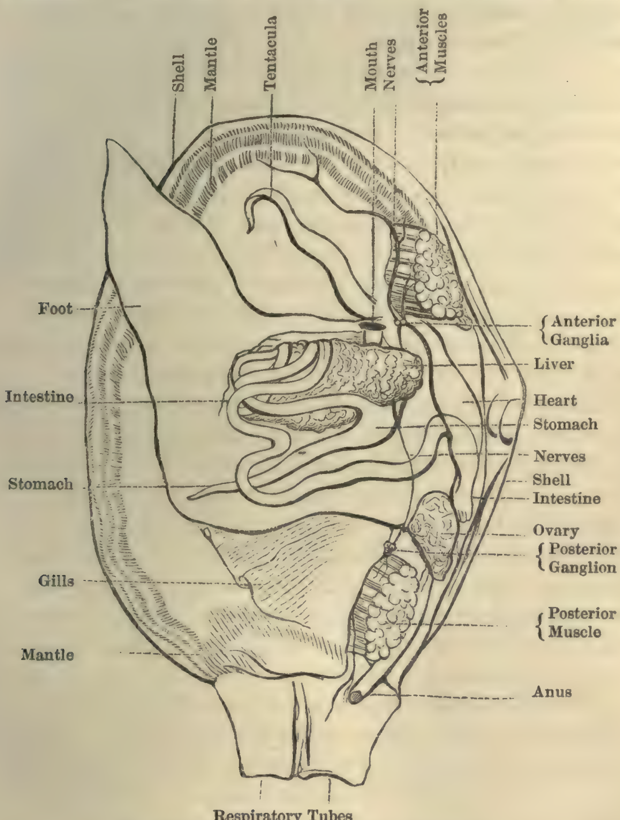


FIG. 586.—ANATOMY OF AN ACEPHALOUS MOLLUSK.

situated near the mouth, the valves can be drawn together with considerable force. The intestinal tube is seen to terminate near the opening at the posterior extremity of the shell, in one of the respiratory tubes, which discharges its contents, and serves for the exit of the respiratory current.

934. The foregoing description will apply, with slight variations, to the structure of almost all Lamellibranchiata; but we have now to notice two organs, which are absent in some, and in others more largely developed than in the present instance. At the left side of the figure, projecting beyond the edge of the mantle, is seen the *foot;* a fleshy muscular organ, somewhat resembling the tongue of higher animals, and not containing any hard support, or being protected by any envelope. This foot, which is the only special locomotive organ possessed by the Mollusca of this class, serves a great variety of purposes; sometimes enabling the animal to leap with considerable agility along a hard surface, sometimes being used to bore into the sand or mud, and sometimes only serving to affix the animal to some firm support. From the base of this foot there proceeds, in the Mussel and its allies, a band of hair-like filaments, forming what is called the *byssus.* These sometimes exist in great abundance, and serve, by being fixed by their extremities to the shore or bottom of the sea, to anchor the shell, and yet to allow the animal considerable freedom of motion within certain limits. Frequently the byssus is altogether absent.

935. The Lamellibranchiata have usually more power of locomotion than the other Acephala. Some of them, however, are attached to one spot during all but the earliest period of their lives. Others adhere by the byssus, or by the foot, by which they obtain a certain range; and others are free during the whole of their lives, swimming and leaping with considerable agility. In these movements some of them appear to be directed by powers of sight; and in these are perceived small red spots at the edges of the mantle, which are believed to be eyes. They do not appear to have much choice of food; nor are they provided with any other means of obtaining it, than the ciliary action, which introduces constant currents of water into the mouth. In general they do not attain any great size, but they are on the whole larger than any Mollusks except the Cephalopoda; and a few species attain considerable dimensions, a *Pinna* having been known four feet long, and a *Tridacne* (Giant Clamp-shell) having been known to weigh 600 lbs. They are distributed over the whole globe,

principally frequenting the shores or shallows. Each region has certain species peculiar to it, or most abundant in it; and there are few which are not limited to one hemisphere. The temperate zone appears as favourable to the development and multiplication of some species as the torrid zone to others; but the largest kinds are only found in warm latitudes.

936. In regard to the subdivision of the Lamellibranchiata into Orders and Families, great difficulty is felt by those by whom this group has been most studied. By some, the presence of a single or double adductor muscle has been taken as the ground of the primary division; but for the reason already stated, this is unsatisfactory (§ 932). By others, the degree in which the two divisions, or lobes of the mantle, are united along their edge, is adopted as the foundation of the arrangement; this also is unsatisfactory for a similar reason, although it is probably a more *natural* character than the other, because it seems to correspond more with the general structure of the animal. Others, again, have taken the degree of development of the foot as their guide; but this, too, if followed alone, would lead into many errors.—The fact appears to be, that it is necessary to consider all these characters *together*, in attempting to make a natural arrangement of this family; and the Author's recent inquiries regarding the structure of the Shell, lead him to believe that this also will afford a character of great importance,—frequently serving to determine the real position of genera, which would otherwise be doubtful. For the present, however, it will be desirable to adopt the following arrangement into ten primary divisions, which has been proposed by M. De Blainville. The names of some of these, however, have been changed; to make them correspond better with those adopted by other naturalists:—

I. The Ostraceæ, including the *Oysters* and their allies. These have the lobes of the mantle open along their whole length, but the body is concealed by the adhesion of the laminæ of the gills; the foot is altogether absent; and there is but a single adductor muscle.

II. The Pectinidæ, or *Pectens* (Scallop-shells) and their allies, which have, like the last, the lobes of the mantle open;

but the branchial laminæ are not adherent; there is but a single adductor muscle; and there is usually the rudiment of a foot.

III. The MARGARITACEÆ, or *Pearl-Oyster* tribe; these, also, have the edges of the two halves of the mantle, and also of the branchial laminæ, free, or not adherent to each other; and there is but a single adductor muscle; but the foot is larger, and a *byssus* is usually present, by which the animals attach themselves to rocks, &c.

IV. The MYTILACEÆ, or *Mussels,* which have the lobes of the mantle adherent posteriorly; the foot small, and provided with a byssus; and a double adductor muscle, of which the anterior is small.

V. The UNIONIDÆ, or *Fresh-water Mussels*, which have the mantle non-adherent, but which have the branchial laminæ united posteriorly, so as to form a sort of siphon for the exit of water. The foot is a large fleshy mass; and there is no byssus.

In the preceding Orders, the *hinge* of the shell was very simple; it now becomes of increased complexity. In all the remaining Orders, the adductor muscle is double.

VI. The ARCACEÆ, or *Arks*, which have the mantle but slightly adherent posteriorly, but adherent along the lower edge of the shell: the foot is large; and both adductor muscles are of considerable size.

VII. The CAMACEÆ, or *Clamp-shells*, have the mantle still more adherent, but always divided by a large opening at the lower part for the passage of the foot, which is of great size. The respiratory orifices are not prolonged into tubes, but are surrounded by a circle of radiating tentacula.

VIII. The CARDIACEÆ, or *Cockle* tribe, which have the lobes of the mantle still partly open in front, but prolonged into tubes at the posterior extremity; these Mollusks have a large foot, which they use for burying themselves in the mud.

IX. SOLENIDÆ, or *Solens*, and their allies, in which the mantle is quite closed in front, so as only to allow the foot to pass out, and is prolonged behind into tubes of considerable length; which can, however, be withdrawn into the shell.

X. The INCLUSA, in which these characters are still further

manifested; the bivalve shell never covers the whole of the body; but frequently the respiratory tubes themselves secrete shelly matter from their external surface, forming a tube with which the valves are often blended (§ 963).

ORDER I.—OSTRACEÆ.

937. The shell of these Mollusca is formed of two unequal valves, connected together by a hinge on which there are no teeth or ridges, and which is therefore of the simplest character. The shell is attached by the most convex of its valves to rocks, to pieces of wood, and even to others of its own kind. This attachment is formed by the exact adaptation of each layer of shell, prolonged beyond the margin of the former one, to the inequalities of the surface upon which it lies; and sometimes the margin is actually made to re-curve backwards, to enter some

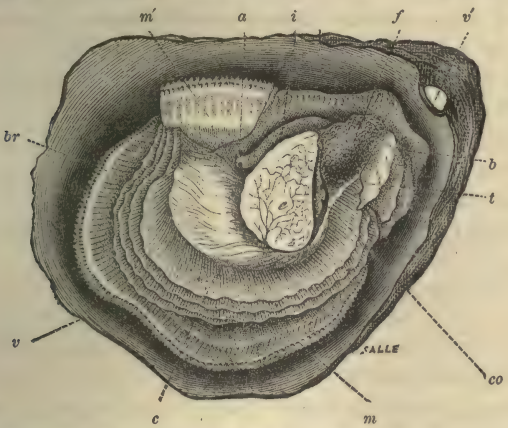


FIG. 587.—ANATOMY OF THE OYSTER: *v*, one of the valves of the shell; *v′*, its hinge; *m*, one of the lobes of the mantle; *m′*, a portion of the other lobe folded back; *c*, adductor muscle; *br*, gills; *b*, mouth; *t*, tentacula, or prolonged lips; *f*, liver; *i*, intestine; *a*, anus; *co*, heart.

furrow by which it may hold more firmly. The animal itself is of very simple structure. No vestige of a foot can be seen; and

the ligament which unites the valves is of small size. On separating the valves, the four rows of gills are observed, forming what is called the *beard*, at a little distance from the fringed edge of the mantle. The adductor muscle is situated at about the centre of the body; and the heart lies between it and the mass of the viscera, and is easily to be distinguished by the brown colour of its auricle. The mouth is to be found beneath a kind of hood, formed by the union of the two edges of the mantle near the hinge. The ovaries are of very large size at breeding time; and one individual produces, according to Poli, 1,200,000 eggs. These eggs appear to be generally developed within the valves of the parent; so that the young Oysters may be often seen swimming slowly in the fluid surrounding the gills, or attached to these organs. According to Leeuwenhoek, each of these is about 1-120th of an inch in length; so that two millions of them closely packed together would not occupy above a cubic inch. He reckoned from 3000 to 4000 to exist in one Oyster at the same time. The principal breeding time of the common Oyster is in April and May, when they cast forth their young in little masses like drops of grease, formed of several united together by an adhesive fluid, upon rocks, stones, or other hard substances that happen to be near; and to these the *spats*, as they are termed by fishermen, immediately adhere, soon forming a thin shelly covering. Very commonly they adhere to adult shells; and thus are formed the large masses termed *banks*. Their growth is very rapid. In three months they are larger than a shilling; and at the end of the first year they have a diameter of two inches. When they are about a year and a half old, they are reckoned fit for the table; and they are then taken by dredges, and stored in pits, where they undergo changes in their condition, which render them more fit for the market. When removed altogether from their native element, they very commonly open their shells, and lose the water retained between them, which occasions their speedy death; but if placed in situations which the tide occasionally reaches, they learn to keep their shells closed in the intervals. Although no special organs of sensation can be detected in them, except the tentacula around

the mouth, they are evidently very susceptible of the influence of light, having been observed to close their shells when the shadow of a boat passes over them.

938. The enormous number of Oysters which exist on our shores, may be best judged of by considering the extent of the *banks* which they form. These beds occupy portions of the sea, in shallow parts, extending for miles in each direction; and in some places, the depth of the stratum is very considerable. A remarkable growth of them exists along the alluvial shores of Georgia, in North America; and their influence in preventing the encroachments of the sea is very important. The marsh land extends inwards for a space of from twelve to eighteen miles; and it is so soft, that an iron rod might be pushed into it without difficulty to the depth of 18 or 20 feet. A great number of large creeks and rivers are found meandering through these marshes; and the bends of these rivers would in a short time cut through the adjoining land to such an extent, that the whole seaboard would become a quagmire. But wherever the tide directs its destroying force, its effects are counteracted by walls of living oysters, which grow upon each other from the beds of the rivers to the very verge of the banks. These hillocks are often found in bunches among the long grass growing upon the surface of the soil. They are in such abundance, that a vessel of a hundred tons might load herself in three times her own length. These banks are the favourite resort of fish and birds, as well as of the racoon and some other quadrupeds. The neighbouring inhabitants will sometimes light a fire upon the marsh-grass, roll a bunch of oysters upon it, and then eat their contents. This barrier of oysters, like rocks of coral, must offer the strongest resistance to the force of the tide. Such immense collections of shells are very interesting when viewed in relation to Geological phenomena; since whole strata of rock are often found entirely composed of shells thus aggregated; which probably occupied, on the shores of the land then upraised above the surface of the ocean, a position similar to that in which we find the oyster-beds at the present time.

939. Notwithstanding the enormous number of Oysters

which thus accumulate, the race would speedily be extinguished by the voracity with which Man preys upon them, were not the destruction counterbalanced by the powers of multiplication already noticed. But Man is by no means the only enemy to the Oyster. Its body serves as food to many marine animals, which have various methods of getting access to it, in spite of its shelly defence; from some of these it can secure itself by closing its valves as soon as it is alarmed; and against others it has a more active means of defence, in the violent expulsion of the water included between them, which (as it is itself fixed) will frequently drive off its opponent. Various animals attack it, also, by perforating its shell; and to these also it can offer a passive resistance, by depositing new shelly matter within. So that even this lowly-organised being, commonly regarded as one of the most vegetative of animals, is provided by its Creator with such means as are necessary for its preservation, and doubtless also for its enjoyment.

940. Nearly allied to the Oyster, but having also some points of resemblance to the class of Palliobranchiata or Brachiopoda, is the genus *Anomia;* which is remarkable for the perforation of one of its valves by a large aperture; through which a great part of the adductor muscle passes, to be inserted into a third plate (sometimes calcareous and sometimes horny), by which the animal adheres to foreign bodies. The valves are thin and of irregular form; being influenced by the surface on which they grow. They are usually found attached to the surface of other shells, especially those of Oysters.

FIG. 588.—ANOMIA EPHIPPIUM.

Order II.—PECTINIDÆ.

941. The *Pectens*, or Clams, are known by the regular radiation of the ribs from the summit of each valve to the circumference; and by the two angular projections, or *ears*, that widen the sides of the hinge. The shell is often very vividly coloured; and a marked difference in hue is frequently observable between the two valves. The animal has a small oval foot; and some species are attached by a byssus; whilst others are said to swim freely through the water by the flapping of their valves, and can even regain the sea by a motion of this kind, when left upon the shore. The large species upon our coast, *Pecten maximus*, is the pilgrim's scallop shell, worn in front of the hat by those who had visited the shrine of St. James at Compostella in Gallicia. Pectens are sometimes eaten; but, as the animal is hard and indigestible, few but the poor employ it as an article of food. The hollow valve has been used as a dish; and even as a culinary vessel, being capable of bearing a considerable heat without cracking.—Among other genera of this family, we may notice the *Spondylus;* in which the shell bears a general resemblance to that of the Oyster; but the hinge is provided with two teeth in each valve, which enter into corresponding depressions in the opposite valve. The shell adheres to solid bodies of all kinds; and its form is modified by the surface of the objects on which it grows. The animal is eaten like the Oyster. The most interesting peculiarity in this genus has been already noticed (§ 870). Many of the species are of very vivid colours.

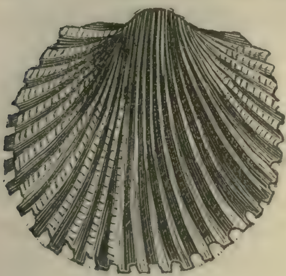


Fig. 589.—Pecten.

Order III.—MARGARITACEÆ.

942. This group contains many genera of much interest; all of them agreeing in the structure of the shell, which is composed internally of nacre, and externally of prismatic cellular substance. The most important is the *Avicula;* which receives its name (meaning *little bird*) from the wing-like projections near the hinge, which are very long in some species (Fig. 590). One species, the *Avicula margaritifera*, produces the most valued Pearls, as well as the greatest quantity of Mother-of-Pearl (the latter being simply the nacreous interior of the shell). The former are separate formations of a similar substance, deposited by the mantle at particular spots, in consequence of some irritation. Various causes will occasion this deposit. If grains of sand find their way between the shell and the mantle, they are generally incrusted by it; one layer being thrown around another, so that, if the calcareous matter be gradually dissolved

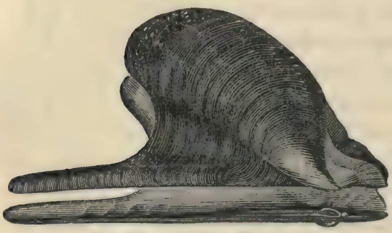


Fig. 590.—Avicula Macroptera.

Fig. 591.—Avicula Margaritifera.

away by a weak acid, a series of concentric spheres of membrane remain. Many pearls, however, inclose no such nucleus; yet still are produced by mechanical irritation of the mantle. It has been observed that, if the shell be penetrated by boring-worms, pearly matter is deposited at the spot perforated; and an artificial expedient was thus suggested, which has been put in practice with a certain degree of success. This was, to obtain

the shells, with the animals alive, to make perforations in them, and then to commit them to their native element. The expense of this proceeding, however, has been found to exceed the profit obtained by it ; especially as the pearls thus produced are seldom possessed of that regularity of form, which is an important element in their value. The best pearls are generally produced at the point, where the attachment of the adductor muscle causes a roughness in the shell. The gradual change which takes place in the position of this muscle, in accordance with the growth of the animal, causes the detachment of the pearl ; and it is generally found imbedded in the substance of the muscle, by the motion of whose fibres its regularly spherical form seems chiefly occasioned.

943. The formation of pearls is by no means confined to the *Avicula margaritifera.* Any shell, univalve or bivalve, with a nacreous interior, may produce them. They have been found in *Patellæ* (Limpets), *Haliotides*, and *Pinnæ ;* and more especially in the *Unios*, which are fresh water shells, abounding in most rivers of the north.* It is the Pearl Oyster, or Mussel, as it has been termed, which is most sought, as furnishing this commercially-important article of luxury. The shell exists in considerable banks in the Gulf of Manaar, on the shores of Ceylon, the Persian Gulf, and other parts of the borders of the Indian Ocean ; and also in the Gulf of Panama, and on the east shore of California. It is attached by the byssus to submarine rocks, usually at considerable depths. The most considerable bed is said to occupy a space of twenty miles opposite Condatchy. To prevent injurious destruction, the bank is divided as it were into regular cuts ; one seventh part being worked every year, so as not to exhaust the bed. The shells are brought up by divers, who, by long practice, acquire the power of remaining under water for four minutes, or even longer ; and in this time they descend to the depth of from four to ten fathoms, pluck the shells from their attachment, and accumulate about fifty in a net sus-

* The River Tay in Scotland affords pearls which are held in tolerable estimation ; although they are much inferior in clearness and lustre to the 'orient pearl.'

pended from the neck to receive them, and they are then drawn up on giving signal to those above. Each diver can repeat this operation about fifty times in one day; but it is not uncommon to see, after several descents, blood streaming from the nose and ears. The shells are laid out that the animals may die; and when this has taken place (which is known by the opening of the shell) the interior is searched for pearls, and the best shells are set by to furnish mother-of-pearl. The produce of this operation is very considerable. In 1798, the pearl-fishery of Ceylon yielded the sum of 200,000*l.*; but the banks seem to have been too much exhausted, as the produce of the subsequent years was much less, and it has not since risen to the same amount.

944. The *Malleus*, or Hammer-oyster, is another genus which is chiefly worth notice on account of its singular form; the two sides of the hinge being extended so as to resemble in some degree the head of a hammer, whilst the valves, elongated nearly at right angles to these, represent the handle. In the *Perna* the hinge has no teeth, but several parallel depressions opposite to each other in the two valves, and lodging as many small elastic ligaments.—Many fossil species of this character, some of them of great size, exist in the Lias, Oolite, and other more recent strata.

945. The *Pinna*, or Wing-shell, approaches the Mussels in many respects. It has two equal wedge-shaped valves, united by a ligament along one of their sides; and is almost entirely composed of the cellular substance formerly described (§ 869). It sometimes attains a considerable size; measuring as much as three feet in length. The most interesting peculiarity of this genus, is the *byssus*, which is remarkably long and silky. The animal fixes itself by this to submarine rocks and other bodies; and lives in a vertical position, the point of the shell being undermost, and the base or edge above. It even attaches its byssus to a sandy or muddy bottom; and in such situations large troops of them are found at the depth of a few fathoms. The most common species exist in the Mediterranean; and the inhabitants of Sicily and Calabria seek them, not merely for eating, but to gather the byssus, of which a stuff may be formed that is

remarkable for its suppleness and warmth. The filaments are extremely fine, of perfect equality of diameter through their whole extent, of great strength, and of a brilliant and unalterable reddish-brown colour. The ancients were acquainted with this sort of stuff; but, in consequence of the diminution in the number of animals, it is becoming very scarce; and, from its expensiveness, it is little more than an object of curiosity.

Order IV.—MYTILACEÆ.

946. In all the Mollusks of this order, there is a foot, which some species employ for locomotion, whilst in others it serves merely to draw out, direct, and fix the byssus. There are also two adductor muscles, of which the anterior one is often very small. The *Mussels*, properly so called, abound on the rocks of our own coasts, to which they are fixed by their byssus; and they are often closely impacted together. Although in ordinary circumstances they have no tendency to change of place, they seem possessed of a certain degree of locomotive power. Reaumur mentions, that in the saline marshes on the sea-coast, where the fishermen throw the Mussels at hazard, they are found at the end of some time united into packets. By putting them into glass vessels, he observed that their mode of progression consisted in thrusting their tongue-like foot out of the shell, curving it, hooking it to some adjacent body, and thus drawing themselves forward to the point of attachment. Although Mussels commonly afford a very wholesome supply of food, they sometimes acquire very poisonous properties. How this is to be accounted for, is yet uncertain. Many instances have occurred, in which a large number of persons have been suddenly attacked with violent symptoms, after eating Mussels from a particular bed; and fatal cases have not been uncommon. Whilst Mussels in general attach themselves to the surface of rocks, &c., others appear to seek out hollows, and imbed themselves there. Others form excavations for themselves in mud; and are found in spots which are occasionally left dry by the tide.

947. The *Lithodomi* are endowed with the power of perforating stone and masses of coral, as well as large shells of other Mollusca. In the earlier stages of life, it is stated by Cuvier, the Lithodomi suspend themselves by their byssus; but when they have pierced the bodies to which they are attached, and introduced themselves into the cavity, the byssus disappears. The excavation does not seem to be here produced by the mechanical action of the shell, which is not adapted for such an office. Nor is there any reason to believe that it is occasioned by a solvent fluid secreted by the animal. It is attributed by Mr. Garner principally to the currents of water constantly impelled against the rock by the vibration of the cilia; and in this supposition there is much probability.—The lithodome Mussels, as well as others, are used as food where they abound; and means have been taken on some parts of the coast, to cause them to multiply. As with Oysters, it appears that the Mussels are rendered more tender, and the quality of their flesh improved, by putting them in places where the saltness of the sea-water is tempered by rain or river-water. Accordingly, on the coasts of France and Italy, regular breeding-places have been established, where those which have been obtained from the sea are cast for a time to improve their quality, and where also the spawn is reared; these are so arranged as to communicate with the sea, but to allow the intermixture of fresh water at pleasure. Like all Mollusca which congregate upon the shores, Mussels serve as an article of food to other animals besides Man. Many sea-birds detach them from their situation by breaking the shell, and then feeding on them. And there are Mollusca of higher Orders, which are enabled to pierce their shells, and which then suck out the soft parts by their proboscis.

948. A Mollusk allied to the Mussel, the *Mytilus polymorphus*, or *Dreissena polymorpha*, has been recently introduced into this country; and affords an interesting example of the complete naturalisation and rapid multiplication of a foreign species. This is evidently due to the variety of circumstances under which it can exist. It is found abundantly in the Black Sea, the Baltic, and other salt inland seas; and it lives, like the Mussel, in

aggregated masses, attached to the bottom by the byssus. But it is also found in many of the large Continental rivers, such as the Danube, the Wolga, and the Rhine; and it thus seems equally capable of living in fresh water. It was first discovered in England a few years since in the Commercial Docks of London, where it was probably conveyed with some timber; and it has since diffused itself through the rivers and canals of the whole island. This may be partly accomplished by its adhesion to the keels of boats.

ORDER V.—UNIONIDÆ.

949. The Mollusks of this Order, frequently called *Fresh-water Mussels*, are for the most part included in the genera *Anodon* and *Unio*. The former is named from the absence of teeth in the hinge, which has merely a ligament along its entire length. The animals are without a byssus; and creep over the sand or mud by means of their large foot, which has three layers of fibres disposed in different directions, so that it has considerable power of altering its form and dimensions. They are most commonly found sunk in mud, however, with that part of the aperture of the shell which corresponds to the mouth directed upwards. It has been said that they have some power of swimming, by striking the water with their valves. The Anodon is viviparous, the eggs being hatched within the shell;

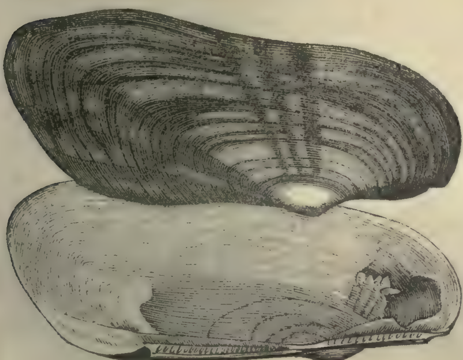


FIG. 592.—ANODON DIPSAS.

and thousands of young ones may be seen in the winter, with a microscope, dispersed among the gills, and opening and closing their shells.—The *Unio* resembles the Anodon in the structure of the shell, and the conformation of the animal; except that the hinge is more complicated. There is a short plate in the left valve, received into a cavity in the right; and behind this a longer plate closing between two others of the opposite side. These, like the Anodontes, inhabit fresh-water, preferring running streams. Several are natives of this country; but they especially abound in the rivers and lakes of North America. The abundance of their nacreous lining causes it sometimes to be employed for the purposes to which mother-of-pearl is applied; and pearls are occasionally obtained from them (§ 943). The animal is of no value as food, from the insipidity of its taste. —Some genera of marine shells have been approximated to the Unio; but as their animals are not known, there can at present be no certainty on this point.

ORDER VI.—ARCACEÆ.

950. The *Arca* is distinguished by its equivalve shell, and by

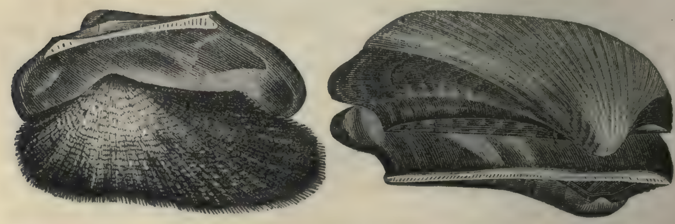


FIG. 593.—ARCA BARBATA AND ARCA NOÆ.

the long line formed by the hinge, which is studded with minute teeth. The valves, which are covered with a velvety epidermis, do not meet in the middle; but a space is left for the passage of a horny, apparently tendinous substance, which seems to replace

the foot, and by which the animals are affixed to submarine bodies. They reside near the shore in rocky places. There are some species in the Mediterranean at the present time; and others abound in the older fossiliferous strata of Italy.—In the *Pectunculus* the hinge has a similar elongated character, but it is curved instead of being straight.

FIG. 594.—PECTUNCULUS.

ORDER VII.—CHAMACEÆ.

951. In this Order are included the largest, and some of the most inert, of all the testaceous Mollusca. Nearly all of them are attached to rocks or other solid bodies, during the greatest part of their lives; some by the adhesion of the shell itself, and others by a tendinous prolongation of the foot, which serves as a byssus. The shell is generally more or less irregular in form, in consequence of these adhesions; its hinge is very analogous to that of Unio, the left valve being provided with a tooth, and further back with a projecting plate, which are received into corresponding prominences in the right valve. The foot is generally very small, and the adductor muscle is double, the anterior one, however, being sometimes rudimentary.—The *Chama* is one of those attached by the shell itself to rocks, corals, and even to masses of similar shells, in the manner of Oysters; and the individuals are thus cemented so strongly to

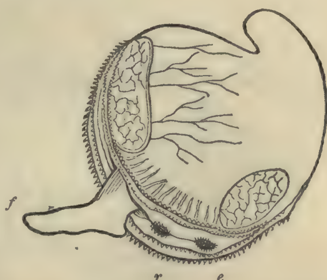


FIG. 595.—CHAMA, with the shell removed, to show the arrangement of the mantle and its orifice. The two lobes are adherent along their entire edges; except at the respiratory passages, *r*, and *e*, and to give exit to the foot, *f*.

each other, that they cannot be detached without breaking the shells. These are subject to changes not only of shape but of colour, in accordance with the accidents of their position. The attached valve is very irregular, and takes the form of the surface to which it is applied; and it is usually much less coloured than the other. The valves have a series of *foliations*, or leaf-like projections, on their surface; and the luxuriancy of these depends upon the stillness of the medium in which the animal exists. If it inhabit deep and placid water, the expansions will generally be of considerable size; whilst those of the individual that has borne the buffetting of a comparatively shallow and turbulent sea, will be poor and stunted. This genus is confined to the warmer seas; the Mediterranean being the locality of the lowest temperature where any species have been hitherto found; the shells have been observed at various depths, ranging from points near the surface to seventeen fathoms.

952. The *Tridacne*, of which one species is the largest known Conchiferous Mollusk, is still more restricted to warm localities; the East Indian and Australian seas alone supplying specimens of it. This is readily distinguished from the Chama by the equality of the valves; since, instead of being fixed by the adhesion of one of these, it is attached, during part of its life at least, by a tendinous byssus that passes out through a channel in the anterior part of the mantle, which forms a well-marked groove in the shell. The *Tridacne*, or Giant Clamp-shell, sometimes attains an enormous weight as well as dimension. There is a pair in the Church of St. Sulpice at Paris, which are used as "*Benitiers*" (receptacles for holy-water), and weigh more than 500 pounds; Lamarck mentions a specimen in which each valve measured three feet by two; so that the story of an oyster which furnished a dinner to a

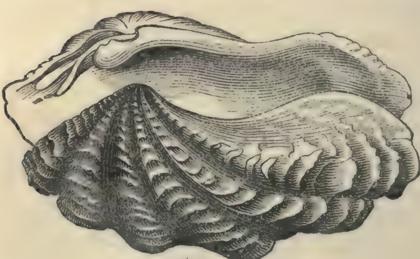


FIG. 596.—TRIDACNE.

whole regiment is scarcely an exaggeration, as the flesh of these animals is commonly used as food where they abound, and is by no means unpalatable. The remarkable difference of the shell of this animal at different epochs of its growth, has given rise to the formation of many species which have no real existence. It is only when immature, and when the shell is comparatively light, that the animal is attached by a byssus. This cord, however, seems rather to be a musculo-tendinous prolongation of the foot itself, than a fibrous tissue secreted by it like the byssus of the Pinna; it is so tough as to require to be chopped with a hatchet, in order that the shell may be detached. As the animal approaches adult age, however, and has by successive layers very much increased the weight of the shell, the byssus, being no longer required to secure it from injury, disappears, and the groove in the shell is filled up with a solid deposit. When thus free, it is said to be taken with a long pole, which is introduced between the valves when open; the animal immediately closes the valves upon it, and does not quit its hold until it is landed.

Order VIII.—CARDIACEÆ.

953. This Order, including the *Cockles* and their allies, contains several genera, which, in the smallness and delicacy of many of their shells, and in the comparative activity of the animals that form and inhabit them, offer a remarkable contrast to those of the previous group. The shells are all equivalve, or nearly so; they are furnished with a regularly-toothed hinge, often of great complexity and beauty; and there is always a double adductor muscle. The foot is here more largely developed than in any of the previous Orders, and it is a very important organ to the animals, most of which use it in the excavation of hollows in the sand or mud of the shores on which they reside, as well as for progression. The respiratory orifices are

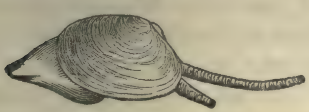


Fig. 597.—Telina.

usually prolonged into tubes (Fig. 597); which can, however, be drawn within the shell by means of a *retractor* muscle.

954. In the *Cardium*, or Cockle, the tubes or siphons are shorter than in most of the other genera; indeed they are sometimes reduced to mere openings; and scarcely any vestige of a retractor muscle exists. The foot is very large, and is capable of being bent at an acute angle, and then suddenly straightened; so as to enable the animal to move from place to place by a succession of leaps. But it is only occasionally, that it serves this purpose. The chief use of the organ is as a boring instrument, by which the animal may penetrate the sand or mud, below the surface of which it is usually found. A very curious provision exists for adapting it to this object. As usually seen, the foot, when extended, tapers gradually to a point; and, as its diameter is at its largest point much less than the breadth of the shell, it is not apparent by what means the hole that is excavated is made sufficiently large for the reception of the latter. This is accomplished, however, by the distension of the foot with water, through a tube which opens just within the mouth; and thus the size of the borer becomes so nearly equal to that of the shell, that (its solid point first entering the sand) it is enabled, by rotatory motions often repeated, to excavate a burrow large enough to receive the animal with its shell. The *Cardia* are found in all known seas; and in some they abound so much, that they become very important articles of food to Man, as well as to marine animals. Mr. Kirby mentions that, on the North East coast of Norfolk, an alteration in the sands has taken place, which has caused a great diminution of late years in the number of boring bivalves; and that the quantity of Soles and other Flat Fish frequenting the coast, of which they form the principal food, has consequently much decreased also.

955. Nearly allied to the Cardium are a considerable number of genera of great interest to the Conchologist; many of them being remarkable for the beauty of their shells, or for the curious situations in which they live. The greater number of them inhabit sand or mud; but there are several which bore into rocks; and a few that burrow in masses of coral. The

means by which they make their excavations, are not understood. The resemblance both in the shell and the animal, among these numerous genera, is often so strong, as to produce a difficulty in their classification, as well as to render it unnecessary to enter here into details respecting them. It will be sufficient to name the genera, *Venus*, *Mactra*, *Tellina*, *Donax*, *Lucina*, *Petricola*, and *Venerupis*, as including the greatest proportion of the group; these being names with which even the ordinary Shell-Collector must soon become familiar, on account of the large proportion that the bivalves of this Order bear to others, on almost every coast.

Order IX.—SOLENIDÆ.

956. The Mollusks of this Order are distinguished from those of the preceding, by the wide gape of their shells at the posterior extremity, and by the length of the respiratory tubes. Their habit is to burrow much more deeply; and their foot (which is of small size) is made to project rather from the anterior extremity, than from the middle of the body; so that the form of the whole is more cylindrical than we have yet seen it, though not so much so as in the succeeding Order. The *Solen*, or Razor-shell, is a well-known example of this group. It has an elongated shell, of which the hinge is furnished with distinct teeth, and the ligament is altogether external. The animal burrows in the sand, into which it sinks rapidly on the approach of danger. It seldom or never quits its hole; and its movements are nearly limited, therefore, to an ascent or descent in it. This it accomplishes by means of its foot, which it elongates and attenuates into a point, when it wishes to bore; contracting it into a rounded form, so as to fix it by its enlargement within the hole, when it desires to rise. The animal is sought for by fishermen on some coasts, as a bait for certain fish. Its burrow is often recognised by the little jet of water which the animal throws out, when alarmed by the shaking of the sand occasioned by the motion of the fisherman above. When the tide is low,

the holes are often seen in considerable numbers; and this is also the time when the animal may be most easily procured. The fisherman throws a little salt upon the hole, which induces the animal to ascend,—according to some, by leading it to the belief that the tide had returned,—and, according to others, by an irritating effect of which it desires to get rid. To seize it when it makes its appearance, some address and quickness are required; for it speedily returns to its burrow; and, if entrapped, its struggles are sufficiently powerful to cause injury by the sharp edges of the shells. If it re-enter its hole, fresh pinches of salt no longer produce the same effect; the animal having either learned by experience that they do not indicate the return of the sea above it, or deeming it better to submit to the irritation than to expose itself to capture. The fisherman then has recourse to a long iron crook, which he sinks pretty deeply; and, drawing it out obliquely, carries away the sand, and the Solen contained in it. If he should fail in this attempt, he knows that to try again would be useless; since the animal instantly burrows rapidly down to such a distance, as to render pursuit of this kind useless.

957. This group is connected with the preceding by the *Mya*, *Lutraria*, and other genera, which are common on our coasts; and which burrow into sand or mud. In the *Mya* and its allies, the two respiratory siphons are united into a single tube, which is of fleshy consistence, and which is covered by an epidermis prolonged over it from the shell. One genus, the *Byssomia*, is remarkable for possessing a byssus at the base of its small foot. The shells of this Order are usually covered with a thick epidermis, or horny skin.

ORDER X.—INCLUSA.

958. The last Order is one of the most interesting of the whole group, as regards the habits of the animals composing it, and the curious varieties of structure which they present. The peculiar disposition of the mantle, which has been noticed as characterising the group (§ 936), has an evident relation with the habits

of the animals composing it; which have the power of forming their habitations, not only in sand and mud, but by excavating wood and rock. No general description can be given of the shells of this group; for although they often bear some resemblance to those of other bivalves, they frequently depart from them so completely, as to leave their character in doubt, until the structure of the animal producing them has been examined. The tubes cannot in any instance be drawn within the valves; and these frequently cover but a small part of the whole surface. We then often find a kind of supplementary shell, formed by a calcareous exudation, lining the hollow which the animal has pierced; and this sometimes involves the original shell, so that the latter is entirely lost in it.

959. As connecting this Order with the preceding, and as departing least widely from the general type of Bivalves, we may first mention the *Pholas*; this has a shell formed of two principal valves, which leave a considerable space between them at each end when they are closed; and of supernumerary pieces, the number and position of which vary considerably. The foot issues at the opening through the larger end; and the respiratory siphons, which are very long and extensible, pass out by the other. Some Pholades form their cells in mud or clay; but many in rocks, and others in wood. It is evident that a fleshy foot can be of little use in the excavation of a stony mass; and the organ here appears to serve a different purpose. The boring operation seems to be performed (in many cases at least) by the shell itself, which has a rasp-like surface, and which is renewed by vital action as fast as it is worn down. In order to make the valves rotate backwards and forwards (like a surgeon's trephine), the foot is affixed to the bottom or end of the hole, and becomes a fixed point from which the muscles can act. They seem to commence this operation almost as soon as they quit the egg; the young beginning to bore the rock on which they are cast, and enlarging their cell, which they never voluntarily quit, in accordance with their own increase in size. They possess a very curious means of freeing the tube from the raspings of the rock produced by their penetration. The siphon

being distended with water, the animal suddenly contracts it; and thus a jet is produced through the anterior orifice, which washes out the part of the cavity occupied by the animal; but, as many of the particles expelled by it are deposited before they reach the mouth of the hole, the passage is found to be lined nearer its entrance with a soft mud.

960. The Pholades evidently prefer such beds, as are composed of indurated clay, or soft lime-stones, to harder lime-stones; though they are occasionally found in the latter. Hence it might be supposed that their action is *always* of the mechanical nature just described; but though it is certainly of this kind in many instances (as is proved by the cylindrical form of the perforation, as also by the rasp-marks on its interior), Pholades are sometimes found so imbedded, that they *could not* have turned in their perforation.—In some countries they are much prized as food; especially along the Mediterranean coast. They possess one remarkable property, which is not, however, confined to them, but which is manifested in a degree by other Mollusca; this is their *phosphorescence*. It is said to be so strong, that persons who eat them raw, and in an obscure or dark place, seem to be swallowing phosphorus. The Pholades are pretty generally diffused over the globe. They usually multiply around any spot which they have begun to frequent; the young produced from the eggs probably boring near their parents. Pholades are not very abundant in a fossil state; but they are occasionally found in tertiary strata, imbedded in the cavities which they have themselves formed.

961. The *Teredo* is a genus which presents many points of interest to the Naturalist, as well as to those who are practically affected by its destructive operations. This animal bears a general resemblance to the Pholas; and it carries on its anterior part a pair of valves, which it uses in the same manner, as perforators of the wood into which it bores. When quite young, it establishes its habitation in submerged timber, such as ships' bottoms, piles, &c., which it perforates in every direction. With its increasing bulk, it enlarges its hole, advancing into the wood; but it does not draw the tubes of the mantle after it, for they remain where they were, and deposit shelly matter, which

lines the cavity ; and thus a complete additional tube of shell is formed, of a length proportional to the age of the animal.* At the entrance of the tube, or the termination of the siphons, there is a pair of *pallettes*, or small valves of shelly structure ; by the motion of which the current of water is maintained, that is necessary to bring a supply of food and oxygen to the animal thus included. The highest point at which they commence to bore, is always some feet below the lowest water-mark ; and they usually work downwards. The orifice, being made when the animal was young, is very small, and often difficult to perceive. The beginning of the tube is usually horizontal or oblique ; and afterwards it curves into a nearly vertical direction. The nature of the wood has a great influence on the regularity and direction of the canal which is hollowed in its interior ; but this is still more affected by the neighbourhood of other Teredines, to avoid whose tubes the animal will make sudden curves. It is difficult to comprehend how it can become conscious of their proximity. There can be no doubt that, in this instance, the excavation is effected by the valves ; since it is always cylindrical, with very smooth walls ; and the shell is adapted, both by its sides and edges, for rasping and boring.

962. These animals are among the most formidable destroyers of the works of Man. When it is considered that their instinct prompts them to attack all the timber which he has, for various objects, placed beneath the surface of the sea, it is seen that the field of their operation is immense. The piles of bridges, piers, and harbours, as well as shipping, are liable to their devastations ; and Holland has been more than once threatened with an inundation, by the destruction of the dykes which they have effected. Many vessels have sprung leaks and foundered, owing to the unsuspected demolition of the planking of their bottoms by the same means. The most effectual protection against their attacks, is a metallic sheathing ; but it is said that piles may be secured by the previous charring of their surface to the depth of a few lines. Different species of Teredo appear to exist in all

* The accessory pieces of the shell of the *Pholas*, may probably be considered as a rudiment of the same structure ; they vary considerably in number and arrangement ; and sometimes appear to form the commencement of a regular tube.

parts of the world; and on the coasts of the Atlantic they are used as food, their flesh being reputed more delicate than that of Oysters. According to Seba, who made his observations in Holland, certain species of *Nereis* (§ 839) are mortal enemies to the Teredines, penetrating into their tubes and devouring them. As a British animal, the Teredo is now nearly or quite extinct; the precautions taken against it having prevented its multiplication; and new importations being checked by the general use of copper sheathing.

963. In the *Gastrochæna*, the valves bear but a still smaller proportion to the shelly tube, which not only covers the part of the excavation posterior to the animal, but lines the whole interior of the hollow, so as to include the valves. This tube is often found in the perforations previously made by some other boring Mollusk, and also in natural hollows in rocks, corals, &c.; but the animal has evidently the power of excavating for itself, if it does not meet with a hole adapted to it.—The *Clavagella* is an animal of analogous structure; but one of its valves is incorporated, as it were, with the shelly tube, the other remaining free. The latter appears to perform by its movements the same kind of function as the *pallettes* of the Teredo.—The *Aspergillum* departs more widely from the general type, than any of the preceding; so that, if viewed out of connexion with them, its true place in the scale would be doubtful. The shell, which derives its name from its resemblance to the spout of a watering-pot, has the form of an elongated cone, terminating at the large end in a disk, which is pierced with a number of tubular orifices; and the tubes of the outer row being the longest, they form a sort of corolla (*a*, Fig. 597) around the disk. At a little distance above this, two small valves (*b*), incorporated in the substance of the tube, are easily distinguished. The smaller end is open, and there is likewise a little fissure

Fig. 598.—Aspergillum.

nearer the larger end; by these apertures the water is freely admitted to the interior of the shell. The animals of this genus are borers. Some of them live in the sand, plunged down perpendicularly for about three-fourths of their length, and supported by the little tubular prolongations, which are supposed to be filled by fleshy filaments of the mantle. Some, again, burrow in stone, others in wood, and others in thick shells.

964. In regard to the Geological distribution of the Lamellibranchiata, it will be sufficient (as in the case of the Gasteropoda) to say, that they make their appearance in the earliest fossiliferous strata; and that, although there is always a difference between the fossil and the existing *species*, until we compare those of the comparatively recent geological periods, the same *genera* are found to have existed in the ocean, from the most ancient times to the present. It is interesting to remark, however, that the proportion which they bore to the Bivalves of the succeeding class, was very small in the oldest fossiliferous rocks, but has since been gradually reversed.

CHAPTER XIX.

OF THE CLASS OF PALLIOBRANCHIATA.

965. THIS Class, although at present very limited,—both as to the number of existing species it includes, and the small number of these which seem to be distributed through the ocean,—was formerly of great importance; since it included a very large proportion of the Bivalve Mollusks of the older rocks. Although an ordinary observer would not detect anything in the structure of the shell, to justify the separation of this class as distinct from the preceding, yet the necessity for this division becomes evident, when the organisation of the animal is examined. The name of the Class is derived from the peculiar conformation of the respiratory apparatus, which here consists of the mantle itself; this is traversed by blood-vessels, which ramify minutely over its surface; and is furnished, especially along its edge, with vibratile cilia, which produce a continual current in the surrounding water, and thus renew it for the aeration of the circulating fluid. In addition to this singularity of structure, the organs for procuring food offer remarkable peculiarities. They consist of two long spiral arms, one on each side of the mouth; the existence of which has given rise to the name BRACHIOPODA or Arm-footed, by which the class is frequently designated. In many species, these are capable of not only being unrolled, but extended beyond the shell to a great distance in quest of food. They are usually furnished with numerous vibratory filaments, for the more certain capture of the prey, and probably also for assisting in the maintenance of the respiratory current—an extraordinary provision, which is rendered necessary by the great depth at which these animals live, and the consequent enormous pressure of the water around. All the existing genera of this class are attached, in some way or other, to solid bodies. In *Terebratula* and

Lingula, this attachment is effected by means of a fleshy tubular footstalk ; and this footstalk or peduncle passes out, in the Terebratula and its allies, through an aperture or notch in the beak of the shell (Fig. 600). In Orbicula, on the contrary, the

FIG. 599.—TEREBRATULA PSITTACEA.

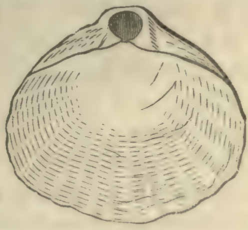


FIG. 600.—CONVEX VALVE OF TEREBRATULA.

peduncle is wanting : and the lower valve of the shell itself becomes the medium by which the attachment of the animal to the rock is accomplished. There is thus the same kind of difference between these genera, as there is between the *pedunculated* and *sessile* Cirrhopods,—a Class, of which we are also strongly reminded by the structure of the arms of the Brachiopoda.

966. The greater part of the existing Mollusks included in this Class, belong to the genus *Terebratula ;* of which about forty species are at present known to exist, but of which several hundred fossil species have been enumerated. These present themselves in the very oldest rocks ; and may be found, in greater or less abundance, in almost all marine deposits, down to the present time. The two valves in Terebratula are unequal, one being nearly flat and the other convex ; it is in the latter, that the opening is found for the transmission of the pedicle ; but the former is still more remarkable for the curious internal apparatus which is connected with it. This consists of a sort of slender framework of shelly substance ; which projects considerably into the cavity of the shell, and to which the arms just now mentioned are attached. This framework is often found in fossil shells, in a beautiful state of preservation. The arms of the ordinary Terebratulæ do not appear to be extensible beyond the shell ; but in the *Terebratula psittacea* (which is probably to

be ranged under another genus) they are enormously developed; and being quite free except at their origin, they may be extended far beyond the shell. When drawn in, they are disposed in six or seven spiral turns. The mechanism by which these arms are unfolded is very curious. The stem of each is tubular, and contains a fluid; which, being acted upon by a multitude of muscles forming the walls of the canal, is forced onwards up the tube, and thus causes the arm to project. We shall hereafter meet with a very similar contrivance, in the numerous tubular feet of the Echinodermata (§ 1007). The Terebratulæ are found in all seas, from the polar to the equinoctial, at a depth of from ten to ninety fathoms, or even more.

967. The *Orbicula* may be noticed as the type of the sessile group. Its two valves differ considerably in form and size; one being conical and rounded, like the shell of the Limpet (with which it was formerly confounded), whilst the other is flat, with a fissure in the centre for the passage of a ligament, by means of which it is fixed to the rocks. The Mollusk has ciliated arms, rolled up spirally when withdrawn. The recent species of this genus are found attached to stones, shells, and sunken wrecks, at various depths, down to seventeen fathoms. They sometimes are found in vast numbers in particular spots.— The *Crania*, another sessile genus, has been dredged up in 255 fathoms' water. These facts are of much interest, when taken in connection with the circumstances, under which the fossil species are found. It may be inferred, from the diminished numbers of this class, that the ocean is at present less fit for their habitation than it formerly was; and perhaps a diminution of depth is one of the circumstances which has given rise to this change.

CHAPTER XX.

OF THE CLASS OF TUNICATA.

968. ALTHOUGH the Mollusca are in general possessed of a calcareous shell, sometimes enveloping the whole body, and sometimes inclosing but a small portion of it, no appearance of such a structure is presented among the animals of the lowest group,—the Class TUNICATA. Feeble as are the powers of sensation and locomotion in a great proportion of the Molluscous tribes, they would seem almost extinct among the members of this group. The greater number of them pass their whole lives in one situation, agglutinated by their external tunic to submarine rocks, or attached by a footstalk prolonged from it; many species associate together, like the Polypifera, to form a compound structure, in which several individuals are united more or less closely; and those which have no fixed attachment enjoy little independent locomotive power, but are driven about at the mercy of the waves. No beings possessed of a complex internal structure, a distinct stomach and alimentary tube, a pulsating heart and ramifying vascular apparatus, with branchial appendages for aerating the blood, and highly-developed secretory and reproductive organs, can be imagined to spend the period of their existence in a mode more completely *vegetative* than these.

969. The animals of this Class are entirely enveloped in a firm elastic *tunic* (whence their name), which is always provided with two orifices. The general form of the body, as well as the colour and consistence of this tunic, vary considerably in the different species. Sometimes it is globular or egg-shaped; sometimes narrow and prolonged. The tunic is often of leathery or even cartilaginous firmness, and of a dark colour; whilst we occasionally find it soft, membranous, and transparent, and of a light greenish tint, so that the clusters of animals look like

bunches of grapes. In the larger species, additional firmness is often given to this tunic, by the agglutination of particles of sand, bits of gravel or shell, or other substances with which it comes in contact, to its exterior; and a complete envelope is sometimes formed in this manner, which might be compared to the shells of the higher Mollusca, but that it is altogether derived from external sources,—the glutinous matter which unites the particles together, being the only part furnished by the animal itself.

970. Within the external tunic is a muscular coat, representing the *mantle*, consisting of fibres crossing one another in various directions, by which compression may be exercised on the contents of the cavity it surrounds. The openings which have been mentioned as existing in the outer coat, penetrate this one also; and they are guarded by muscular fibres, arranged in a circular manner around them; by the action of which rings, they may be entirely closed.

971. The cavity of the mantle is principally occupied by a large bag, composed of a delicate membrane, over which the blood-vessels are minutely distributed; this evidently replaces the *gills* of higher Mollusca, and it is accordingly termed the *branchial sac*. It is closely adherent to the mantle around one of the orifices, which leads directly into it, and which is therefore called the *branchial orifice* (*a*, Fig. 601). It also receives support from it elsewhere; but it by no means occupies the whole of the cavity. There is a considerable space at the bottom of it, which is occupied by the digestive and reproductive viscera; and there is also a space in the neighbourhood of the second orifice (*b*), which serves for the discharge of several different *egesta*,* and may thence be termed the *funnel* or vent.— The branchial sac is probably to be regarded as formed by a dilatation of the pharynx, or funnel-shaped commencement of the œsophagus; and the branchial orifice as the real mouth. We shall hereafter see, that a very near approach to this structure is presented by certain Polypes (Fig. 624).

972. The entrance to the digestive tube, lies at the bottom of the branchial sac; and the alimentary particles are derived

* Fluid or solid matter to be *carried out* of the system.

from the water introduced into it for the purpose of respiration. The œsophagus is short, and leads to a capacious stomach, surrounded by clusters of biliary follicles (ANIM. PHYS. § 356), the rudimentary form of a liver. The intestine generally makes one or two turns in the space between the branchial sac and the mantle; and terminates in the neighbourhood of the funnel. The ovaria are usually large, and lie amongst the viscera; their excretory duct also terminates in the same situation. The funnel thus serves to carry out of the cavity of the mantle, not only the fluid stream which has passed over the walls of the branchial sac, and has served its purpose in aerating the blood, but also the solid particles which are rejected from the alimentary canal, and the ova which are discharged when mature from the ovaria.

973. Between the two orifices there is a nervous ganglion, which sends filaments to each of them, and distributes its principal branches over the general surface of the mantle. No organs of special sensation, however, are perceptible; and the only indication of common sensibility shown by these animals, is the contraction of the mantle when they are touched, by which the water contained in the branchial sac is spirted out, sometimes to a considerable distance. Sometimes a number of them are so closely impacted together on the rocks, that the impression given to one causes it suddenly to retract, which acts also on the one next to it, and so on throughout several of them; and each in contracting throws out a quantity of water. After the contracting force has ceased to operate, the usual form is restored by the elasticity of the tunic.

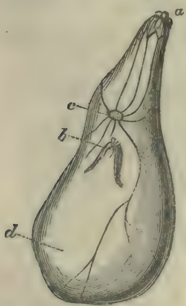


FIG. 601.—NERVOUS SYSTEM OF ASCIDIA; *a*, branchial orifice or mouth; *b*, vent; *c*, ganglion; *d*, mantle (the external coat being removed).

974. No regular movements of this kind, however, are commonly employed, either for the respiratory process, or for the prehension of food. A continuous and equable current of water enters the branchial orifice, and is propelled by the funnel, without any other physical agency that can be perceived, than the

vibration of the cilia which cover the aerating surface. It is from this constant action, that the unattached species appear to derive the slight amount of independent locomotive power which they possess. In these, the two orifices are usually at the opposite extremities of the body; and the continual suction of water into one end, and the discharge of it from the other, will of course tend to propel the body forwards. This movement is most evident when several are associated together, all having their branchial orifices and funnels in the same direction. In the *Pyrosoma* (§ 983), a number adhere together so as to form a tube closed at one end, into the interior of which the funnels of all the individuals open; whilst the branchial orifices project from the outside as so many little papillæ. The water drawn in through these is discharged into the central canal; from the end of which a constant stream issues, with sufficient power to cause the movement of the mass in the opposite direction,—a movement which its brilliant phosphorescence allows to be watched from some distance.

975. Although the Tunicata have been variously placed by different Naturalists, the additions which have been recently made to our knowledge of their organisation leave but little doubt, that their true place is on the border of the Sub-Kingdom Mollusca, connecting it with the Radiata. For, whilst its higher species present many points of resemblance to the lower forms of the Conchifera, its inferior tribes approach equally closely to the Polypifera—not only through the structure of the individuals, but in the examples they present of the union of a number of independent beings to form a compound animal. So prevalent, indeed, is the tendency to this association, that it may almost be regarded as the peculiar character of the group; and, when thus viewed, it presents a very good illustration of the general principle formerly laid down (§ 42, 43). We may regard the Tunicata, then, as an aberrant group of Mollusca; engrafting, as it were, upon the general character of that Sub-Kingdom, the peculiar tendency of the group of Radiata towards which it verges. The tendency to aggregation exhibits itself among the Tunicata in various ways. Sometimes we find a number of individuals

simply adhering externally, but forming a mass of a certain regular aspect. In other cases, we observe several individuals included within a common envelope,—their own external coats being absent. And in some instances, there is a continuous circulation of blood among several individuals, through vessels passing along a stem, with which they are all connected by short peduncles or foot-stalks.

976. The Tunicata may be better subdivided according to the anatomical characters, and the mode of existence, of the respective species, than by arranging them according to their solitary or united condition. On this principle two Orders will be formed; one including the isolated and aggregated *Ascidiæ;* and the other, the isolated and aggregated *Salpæ.* The prominent differences in these two Orders are these. In the *Ascidiæ* the two orifices approach one another more or less closely (Figs. 601, 602). The body is either fixed immediately to some solid mass, or attached to it by a peduncle. And the branchial apparatus consists of a simple sac or bag, occupying the greater part of the cavity of the mantle, and having the entrance to the œsophagus at its lower part. In the *Salpæ* (Fig. 603), on the other hand, the two orifices are placed at the opposite extremities of the body, which is generally more elongated than in the Ascidiæ. They seldom attach themselves to any fixed basis, but rather to floating bodies; and many of them seek no support from other masses, but trust themselves to the waters of the ocean, in which they seem to have some power of spontaneous motion. Instead of a capacious but simple branchial sac, we find a long narrow tube, in which a riband-like fold of vascular membrane stretches from end to end, and serves as the special apparatus for the aeration of the blood.

977. It is among the solitary *Ascidiæ,* that the highest organisation presents itself, which occurs in this family. The two orifices are both evident on the upper part of the body; but the branchial aperture is the most prominent. Within this may be observed a fringe of tentacula, which are sometimes of considerable length and minutely divided, sometimes short and simple. Their office appears to be, to guard the entrance to the

respiratory sac; and it would seem probable that substances unfit to enter it are kept out by the closure of the muscular ring, excited through the nervous apparatus by irritation of the tentacula (ANIM. PHYSIOL. § 436); beyond these, no organs of sense can be detected. The solitary Ascidiæ are found in all climates; they generally frequent the shallow waters of the shore, so as to be occasionally left uncovered by the tide. In some localities they are so abundant, as to afford an important source of nutriment to Fishes; and some species are employed as food even by Man. The power of ejecting the contents of the branchial sac is their principal means of defence. Some of the larger species are able to shoot the fluid to a height of three feet; and thus the person who places his hand upon one of them, is very likely to receive a deluge of water in his face. We are not justified, however, in attributing this action (as some have done) to any *intelligence* on the part of the animal. It is the only movement which these simple beings can perform; and is evidently a reflex action, which any bodily irritation, whether internal or external, will excite. Some of the Ascidiæ have the power of changing their hue; the *Cynthia Momus*, for instance, is sometimes white, sometimes orange, and sometimes of flesh colour.

978. The *Ascidiæ* are not all, however, solitary in their habits. The accompanying figure represents one of the *compound* forms; in which different individuals are united together by a common stem, in the same manner as the Polypes of the Sertularia (Fig. 615). Each has its own heart, respiratory apparatus, and digestive system; but each is fixed on a footstalk that branches from a common creeping stem, through which a circulation takes place that connects them all. The integu-

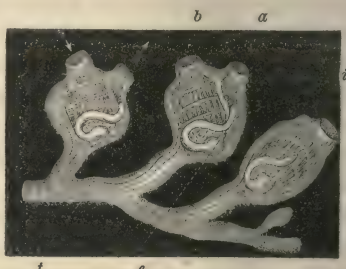


FIG. 602.—POROPHORA, a compound Ascidian; *b*, branchial orifice, or mouth; *a*, anal orifice; *e*, stomach; *i*, intestinal canal; *t*, common stem.

ment is so transparent, that the whole interior and its living actions may be observed without difficulty.—As in other Ascidiæ, the branchial sac occupies a large part of the cavity of the mantle; at the sides and point, however, a vacant space exists between these two membranes, which terminates in the funnel. The sac is perforated with four rows of narrow oval openings, the edges of which are thickened, and fringed with closely-set cilia.—Through these openings, a part of the water which flows into the sac by the branchial orifice, escapes into the space between the sac and the mantle, and is thus discharged immediately by the funnel. Whatever little substances, alive or inanimate, the current of water brings, flow into the sac, unless stopped by the tentacula at its entrance, which do not appear fastidious. The particles which are admitted usually lodge somewhere on the sides of the sac, and then travel horizontally (by some unseen agency), until they arrive at the part of it, down which the current proceeds into the entrance to the stomach, which is situated at the bottom of the sac. Minute animals are often swallowed alive, and have been observed darting about in the cavity, without any apparent injury to themselves, or to the animal which incloses them, for some days. In general, however, particles which are unsuited for being received into the stomach, are ejected by the sudden contraction of the mantle,—the funnel being at the same time closed, so that they are forced out by a powerful current through the branchial orifice.

979. It is in the Circulating apparatus, that the chief peculiarities of these compound Ascidiæ present themselves. The creeping tube which unites the individuals of a group, contains two distinct canals, which send off branches into each peduncle. One of these branches terminates in the heart, which is nothing more than a contractile dilatation of the principal trunk. This trunk subdivides into vessels, of which some ramify over the branchial sac, branching off at each of the passages between the oval apertures; whilst others are first distributed to the stomach and intestines, and the soft surface of the mantle. All these reunite, and form a trunk which enters the peduncle, and constitutes the returning branch. The circulation through these

tubes, however, does not take place constantly in the same direction. At some periods the heart may be observed to contract from behind forwards, so as to propel the blood in the direction just mentioned. After a short time the pulsations become fainter for a few beats, and the flow slower; and suddenly, but with a slight pause, the whole current in all its windings is reversed. The heart gives the opposite impulse; the channel in the peduncle that before poured in the blood now carries it back; and the other, the contrary. These changes succeed each other alternately, the average time being the same in both directions; but the period of each varying as much as from thirty seconds to two minutes. By this circulation, all the individuals in one group seem to be connected. As in the compound Polypifera, increase takes place by sprouts or buds (of which a small one is seen at the right hand of Fig. 602); and the two streams of the stem run through the bud, before its organs are developed. The circulation in each individual appears, however, to be independent of the rest; for it continues when the current through the stalk is interrupted. The stream which returns from the branchial sac and the viscera, is then poured into the posterior part of the heart, instead of entering the peduncle. The circulating system then resembles that of the isolated Ascidiæ; and it is remarkable that the regular alternation of the flow may be observed in these also, in every instance in which the integument is thin enough to allow the current of blood to be distinguished.

980. A closer apparent union between the individuals may be observed in the *aggregated Ascidiæ;* though it may be doubted whether the real connection is as intimate as in the species just described. In these we find a large and variable number of individuals, arranged with more or less regularity within a common envelope. Like the true Ascidiæ, they are all fixed; sometimes forming a slimy crust upon Algæ, or other submarine bodies; sometimes projecting in conical or globular masses; and not unfrequently spreading over the larger isolated species of Tunicata. They agree with them, also, in the relative positions of the branchial orifice and the funnel, and in the structure of the

respiratory chamber. The individuals are occasionally connected by a gelatinous flesh, like that which exists in many of the compound Polypes; and there is even sometimes found a calcareous deposition in this connecting substance, which would still more closely establish their affinity with that group. It has been recently shown, also, that all the individuals in these compound masses originate by *germination*, or budding, from a single one.—Both in the solitary and compound Ascidians, the young animal, when it first issues from the egg, has active powers of locomotion, being provided with a large tadpole-like tail, by the stroke of which it is propelled through the water. Thus a provision is made for the general diffusion of these animals, which would be otherwise crowded in particular spots.

981. The *Salpæ* are animals of greater delicacy of organisation than the greater part of the Ascidians. They are usually so transparent, that the interior structure may be examined through their tunic with little difficulty. They consequently seldom possess any decided colour, except when viewed in a bright sun-light; and then they present splendid iridescent hues.

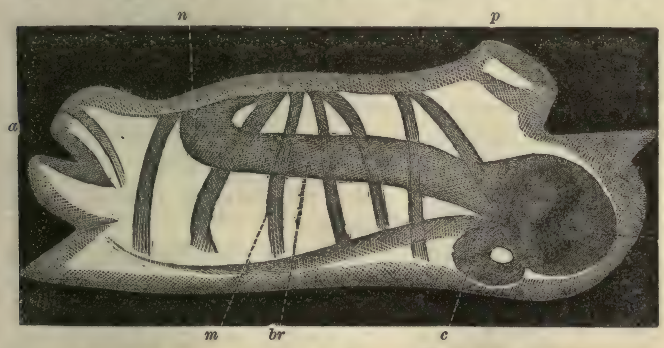


FIG. 603.—BIPHORA, ONE OF THE SALPÆ; *a*, mouth; *p*, posterior or anal orifice; *f*, liver, inclosing other viscera; *c*, heart; *br*, branchial sac; *m*, muscular bands; *n*, nervous ganglion.

They have all one dark spot, however; generally of a brownish-yellow colour. This, which has been termed the nucleus, is occasioned by the opacity of the liver, and its coloured secretion. The branchial orifice possesses no tentacula; but these are

replaced by a kind of valve, which permits the entrance of water and prevents its return. By the constant action of the respiratory apparatus, a considerable degree of locomotive power is obtained for these animals, without any special apparatus for the purpose. There do not appear, however, to be any sensory organs by which the animals can be directed towards their food; and we can scarcely suppose, therefore, that their movements are governed by an intelligent will.

982. The Salpæ are most abundant in tropical climates. Messrs. Quoy and Gaimard relate having seen on one occasion, not far from the Cape of Good Hope, long zones of a reddish-brown colour traversing the surface of the ocean, as far as the eye could reach. These were found, on examination, to consist of minute Salpæ, each not more than two or three lines in length, aggregated together in bands. The colour was given by their nuclei, which did not exceed millet-seeds in size. These bands are driven through the ocean by the action of the waves; and they seem to have a remarkable power of preserving their continuity, even when a considerable force (for animals of such delicacy) is applied to separate them. In fact, the connection is so strong in some species, that it is easier to tear the animals themselves than to part one from another; although their union is accomplished only by the adhesion of their surfaces, or of little suckers, adapted to meet each other, and not by any structural connection. In other species, the adhesion is less powerful; so that when a mass is placed in a vessel of water, and the sides of it are smartly struck, the individuals fall asunder.

983. Nearly all of the *Salpæ* are phosphorescent, or self-luminous; and the small aggregate species are usually more so than the large isolated ones. The bands which they form are, consequently, among the most brilliant of those luminous tribes, which occasionally give such a sparkling lustre to the waters of the ocean. The Salpæ, when thus chained together, produce the effect of long ribands of fire, sometimes drawn straight in the direction of the currents, sometimes twisted and almost doubled by the action of the waves. One of the most brilliant combinations of Salpæ, however, is that which forms the *Pyrosoma*. This

is a hollow cylinder, from five or six to fourteen inches in length, and composed entirely of minute animals of this form. These are aggregated together in the following manner. A number unite, like the radii of a star, so as to form a circle with a central space, into which the vents of all the individuals open,—their mouths being at the circumference. Several of these circular clusters are piled one on another, the central aperture of all of them corresponding so as to form a tube; and through one end of this tube (the other being closed) a constant current of water is forced out by the united ciliary action of all the individuals,—thus causing the mass to move through the ocean in an opposite direction. The Pyrosoma is never met with but in the open sea; and then it often occurs in troops composed of a great number of these masses. "Nothing can be more brilliant, sparkling, and lively, than the phosphoric light which these animals emit. They often form long trains of fire, from the manner in which the masses are disposed in cordons. But a more singular phenomenon attached to this phosphorescence is, that the colours vary instantaneously, passing rapidly from the most lively red to the principal tints of the solar spectrum, to the crimson of the morning, to orange, to greenish, to azure blue, and finally to opaline yellow, when the mass is, to all appearance, in a state of absolute repose."

984. None of the Salpæ at present known are attached to each other by continuous blood-vessels, like those of the compound Ascidiæ (§ 979). It is remarkable, however, that the same alternation in the direction of the circulating current takes place in them, as that formerly described. In fact it may be regarded as characteristic of the Tunicata; since it has been observed in every species, in which the current of blood has been traced.

985. One of the most curious circumstances in the economy of the compound *Salpæ*, is (if there be no error in the account of it) that which has been described by Chamisso in regard to their mode of multiplication. He states that most of the species present themselves under a double form;—a race of isolated animals;—and another of aggregate masses composed of nume-

rous individuals. These last are so unlike the individuals of the separate race, that they might be regarded as distinct species. Nevertheless it is found that the associated individuals produce eggs, from which the solitary *Salpæ* are developed; and that these in their turn produce chains of eggs, from which the riband-like groups originate;—these last, again, giving birth to the solitary race; and so on alternately. Thus, a *Salpa* which differs equally from its parent and its own progeny, resembles its grand-parent, its grand-children, and its own brethren.

CHAPTER XXI.

GENERAL CHARACTERS OF RADIATA.

986. THE *Radiated* subdivision of the Animal Kingdom may be regarded as, on the whole, a very natural group. It includes all those animals, in which there is a regular disposition of similar parts around a common centre, as in the Star-fish (Fig. 606), or Sea-Anemone (Fig. 617). In the most characteristic forms of this group, these parts are but repetitions of each other; and one or more of them may be removed without injury to the functions of the rest. It is by no means uncommon to meet with Star-fish, which, by some accident, have been deprived of a ray, and yet appear to have suffered but little inconvenience from the loss. In most of the Radiata, the parts so lost are replaced by a new growth; and not unfrequently it would appear that these parts may themselves reproduce the whole structure. Here, then, is an important character, which evidently displays an affinity with the Vegetable Kingdom. In Plants we observe that the whole structure is made up of an assemblage of similar parts—the leaf-buds—which may almost be regarded as distinct individuals; for though, whilst associated, they contribute to form a structure which is common to all, and share alike in performing the functions of that structure, yet they may be separated from it and from each other without the loss of their vitality, if placed in circumstances favourable to their growth under this new condition. We shall presently observe that, in the POLYPIFERA, compound structures are produced by the association of individuals, which have very nearly the same relation to each other, and to the whole mass, as exists amongst the buds of a tree, and between these and the woody trunk and branches.

987. But it is not only in this repetition of similar parts, that we may trace an affinity between the RADIATA and Plants. The

resemblance is manifested, also, in the regular disposition of these parts around a common centre, which may be termed *circular symmetry*. The tendency to this kind of symmetry exists throughout the Vegetable Kingdom; being most obvious in the arrangement of the parts of the flower (VEGET. PHYSIOL. § 463). That the Radiata should preserve the mode of development, which is so remarkably characteristic of the Vegetable Kingdom, is not surprising, when we reflect upon the very small proportion which their animal functions bear to those of organic life. None of them possess any high degree of sensibility; and whilst many of them are fixed like plants during a part or the whole of their existence, none possess any very active powers of locomotion.

988. Although the radiated form may be observed in certain members of every class which has an undoubted claim to admission into this group, it by no means follows that it should exist in each individual of those classes. Like every other natural character, it is subject to modifications. The species which present it in the most remarkable degree may be regarded as the *typical* forms of their respective groups; whilst others, in which it is less evident or altogether absent, serve as connecting links with those divisions of the Animal Kingdom which are formed upon a different plan. Thus, among the POLYPIFERA, the *Sea-Anemone*, and many of the associated animals resembling it, have a most regular arrangement of similar parts, both externally and internally, around a common centre. On the other hand, there is an important group of Polypes, which, with the same circular arrangement of the tentacula or arms round the mouth, presents, in its more complex digestive apparatus, an entire departure from that regularity; and through this group we are led, by almost imperceptible gradations, to the MOLLUSCA.—In like manner we have, in the *Star-fish*, a perfectly symmetrical disposition of all the organs of the body. The stomach, situated in the centre, sends a prolongation into every arm; the absorbent vessels which arise from its walls are united in a central ring, and are distributed on a uniform plan in each ray; the nervous system has a similar central ring, and sends equal branches in every direction; the locomotive organs are the same in each

division of the body; and at the extremity of each ray (in the species possessed of visual organs) an eye of equal size exists. But in the *Echinus* (Fig. 604), with an equally symmetrical exterior, we have a somewhat irregular distribution of the contained digestive viscera. And in the *Holothuria* (Fig. 608) we observe that the general form of the body is approaching that of an Articulated animal; although the radiated disposition of parts is still evident around the mouth.—Not unfrequently it happens that the Radiated form is so completely departed from in particular instances, that we should hesitate in referring the animals to this group, if we were not able to trace the links which connect them with forms unequivocally belonging to it.

989. In these remarkable *aberrant* forms we perceive indications of a presiding Unity of Design, even more remarkable than those furnished by the beings whose regularity of structure is more apparent. It would seem but a comparatively simple matter to devise certain *types* of conformation, and to sketch out a number of forms presenting slight deviations from these types. But to combine forms essentially dissimilar, and to modify the organs respectively peculiar to them, so that their functions may go on with that perfect harmony which is essential to the continuance of their existence,—appears (to our human apprehension at least) a more striking display of Creative power; and the regularity of the original design becomes still more wonderful, when it is traced by the eye of the Philosophic Naturalist, through the *apparent* irregularity of its results. In this respect we may compare the Organised Creation with the Solar System; and we may fearlessly ask, whether the mind capable of enjoying such contemplations, does not derive a far higher satisfaction from considering the principle of mutual attraction as the cause, not only of the *regular* movements of the planets round the sun, but of those *perturbations* which are balanced against each other with so astonishing a precision—than it would receive from the mere view of any unconnected series of motions, perfectly regular in themselves, and destitute of influence on each other.

990. There is one very aberrant group, however, which, if received into the Animal Kingdom at all, must be associated with the Radiata, unless we create a new subdivision expressly for it.

This is the *Sponge* tribe, which has been united by Blainville with some others into a group, which he terms *Amorphozoa*, or form-less animals. It is through these curious beings, that the connection between the Animal and Vegetable Kingdoms is most completely established. These Kingdoms approach each other, not through the most perfect forms of either, but by the most simply-organised members of each. Among the lowest Plants, the greatest indefiniteness of form prevails; and we are prepared to expect, therefore, a similar indefiniteness in the lowest groups of Animals. This obviously results, in both cases, from the low degree in which distinct or special organs are developed. In proportion as each minute division of the structure performs all the functions essential to its life, it will be independent of the rest; and the whole structure will thus approach the condition of an inorganic mass, in which each particle exists *by* and *for* itself, and of which the form is entirely determined by circumstances external to it. The *Sponges* have a much closer connection with the group of Radiata, than they have with any other division of the Animal Kingdom; for one of the divisions of the Polypifera may almost be regarded as consisting of Sponges advanced to a higher grade of organisation. We may, then, place them on the border of this group; in such a position as to stand at that extreme edge, as it were, of the whole Animal Kingdom, which approximates the Vegetable Creation.

991. There are certain other forms of this group which, on a cursory view, would seem as little characterised by the Radiated structure as the Sponges themselves. When we look at a mass of branching *Coral* of any description (Fig. 623), we at once perceive its resemblance in form to the productions of the Vegetable Kingdom, and we are at a loss to detect *any* regular arrangement of its parts,—still less that *circular* symmetry for which we are seeking. But we must remember that this structure is merely the frame-work, which connects a number of individuals capable of existing separately; and it is in *these*, that we must seek for the radiated conformation. This we find very distinct in the Polypes themselves; and, in one group, it is marked in the stony cells which they form (Fig. 619).

992. If we ascend from the lowest to the highest RADIATA,

we may observe a progressive removal from the Plant-like condition, in which the simplest of these beings exist. This elevation is manifested in two ways;—in the gradual complication of the nutritive system; and in the evolution of those powers of sensation and independent motion, which differ from any faculties exhibited by vegetables. We shall notice that, whilst in Sponges the tissue is nourished simply by the introduction of the surrounding fluid into the channels of its substance —a mode differing but little from the absorption by the roots and general surface of plants—the Polypes are furnished with a regular stomach, and with prehensile appendages for conveying into it solid nutriment, on which it exercises a most powerful digestion. In the larger and more solid Echinodermata, this complexity of organisation becomes more distinct; the tissues, instead of consisting of soft and nearly homogeneous membrane, exhibit all the varieties of nerve and muscle, tendon and ligament, distinct vessels and cartilaginous or even bony skeletons. The stomach, instead of being a simple bag into which everything is introduced that comes within the animal's reach, whether it be digestible or not, is but the commencement of a regular alimentary canal, furnished with a set of teeth at its entrance for the reduction of the food, and with glandular appendages for the secretion of the fluids required in the digestive process. And we even find distinct organs appropriated to the aeration of the blood, which sometimes present a very complex arrangement. Now it is remarkable that, with so great an advance in the organisation of the nutritive apparatus, we should find the locomotive and sensorial powers very little developed even in the highest; so that in this respect they are far surpassed by the simpler Articulata, whose general organisation is much inferior. But it must be remembered that the perfection of the locomotive apparatus is the distinguishing or *typical* character of the Articulata, and that everything is made subservient to it; whilst conformity with the Plant-like condition seems to be equally the typical character of the Radiata;—being only departed from in those higher forms, which conduct us towards other groups.

993. In looking at the apparatus, by which the various bodily movements are effected, that are concerned either in obtaining food, or in changing the place of the entire body, we observe a considerable diversity in the Radiated classes. In the lowest, the whole tissue appears equally contractile; whilst, in the highest, a distinct muscular structure exists, in which this contractility specially resides. There is another very remarkable structure, however, which is widely diffused through the group; and which enables very active movements to be performed by animals, in which no distinct muscular structure can be detected. This is termed the *ciliary* apparatus; and, as its extensive diffusion through almost the whole animal kingdom, and great importance in the economy, have only of late been recognised, it will be desirable that we should pause here for a short time, to examine its nature in some detail.

994. The organs termed *cilia* are little hair-like filaments, covering the surface and fringing the edges of various membranes both external and internal, which are in contact with fluid; and in this fluid they produce, by their vibrations, currents which may serve various important purposes in the economy of the animal. In the active and free-moving Infusorial Animalcules, the cilia on the exterior of the body are the principal, if not the only organs of locomotion; in the Polypes, fixed to a particular situation, and unable to go in search of food, the currents which they produce in the surrounding element bring it within reach of their tentacula or arms; and in all animals modified for respiration in water, from those simple structures in which no particular division of the surface seems appropriated to this function, to Fishes, and the larvæ of Batrachia (§ 481), their movements appear to have an important relation with it, in constantly renewing the stratum of water in the neighbourhood of the aerating surface. Cilia are even found on the mucous membrane lining the trachea, and ramifying air-passages of the higher Vertebrata; and their use appears there to be to convey the secretions and foreign particles, if such should be present, along the surface. They have also been observed in the upper part of the alimentary canal of Reptiles, throughout its whole extent in the Mollusca,

and in the stomach and its appendages in the Asterias, as well as in many other situations.

995. The presence of *cilia*, when they are moving with rapidity, can frequently be inferred only from the eddies which they produce in the neighbouring fluid. Sometimes the return-stroke, which is made more slowly, can be seen when the direct-stroke is too rapid to be followed. This is particularly the case with the wheels of the Rotifera (§ 537), which appear to revolve continuously in one direction, from the observer being only able to trace one set of the vibratory movements of the rings of cilia which compose them. In general, however, the cilia may be best seen when their motion slackens; and their shape, size, arrangement, and manner of moving, may then be distinguished with tolerable accuracy. Their figure is that of slender filaments, sometimes a little flattened, tapering gradually from the base to the point. Their size is extremely variable, the largest being about 1-500th of an inch long, and the smallest being stated at 1-13000th. They are generally arranged in regular order, sometimes in straight rows, sometimes spirally or in circles; and they are usually set pretty close together, so as even occasionally to resemble continuous fan-like membranes. When in motion, each cilium appears to bend from its root to its point, returning again to its original state, like the stalks of corn when depressed by the wind; and when a number are affected in succession with this motion, the appearance of progressive waves following one another is produced, as when a corn-field is agitated by frequent gusts. Mr. Lister has described the action of the cilia, which surround the respiratory apertures in the branchial sac of a compound Ascidia (§ 978), as resembling that of delicately-toothed oval wheels revolving continually in the same direction; the movement ascending on one side, and descending on the other. But the cilia are very much closer than the apparent teeth; and the illusion seems to be caused by the fanning motion which is given to them in regular and quick succession. This will produce a series of short waves, of which every one corresponds to an apparent tooth. The movement of the cilia is sometimes, however, of a different kind. The point of each describes a circle,

the base remaining fixed; so that the whole cilium describes a cone, of which the apex is at its point of attachment.

996. The movement of the cilia appears to be, in some instances, completely under the control of the animal; and in other cases, to be quite independent of the will, being seen after death, and proceeding with perfect regularity in parts separated from the body. Its duration then varies according to the species in which it is observed; and it is influenced by many external circumstances. It has been seen fifteen days after death in the Tortoise, when putrefaction was far advanced; and in the River-Mussel it seems to endure with similar pertinacity.

997. The Classes which exhibit the Radiated disposition of parts most distinctly, and which are, therefore, unquestionably to be referred to this Sub-Kingdom, are the following:—

I. ECHINODERMATA, or prickle-skinned animals. This Class, which includes the *Echinus* (sea-egg or sea-urchin), the *Asterias* (star-fish), and many less known forms, displays the radiated structure in its most characteristic form. The bodies of these animals are covered with a firm integument, which is thickly beset with spines; and from this, the name of the Class is derived. In many species this integument consists of calcareous plates, regularly jointed together; and in all it possesses greater toughness, than we elsewhere meet with in the Radiated Sub-Kingdom. This is a character by which they are easily recognised, and are well known. There are, however, a few species in which it is less apparent,—the skin having no greater consistence than that of thin leather; but these are associated with the more typical forms, on account of their similarity in internal structure.

II. ACALEPHÆ (sea-nettles), the Jelly-fish tribe. These animals all live singly, and are well-known inhabitants of our seas. They consist of an extremely soft gelatinous tissue; and this is rarely supported by any harder substance. They float freely in the water; and some of them have considerable locomotive power. The common *Medusæ* exhibit the radiated character with great distinctness. In others it is less apparent.

Nearly all of them possess both a stinging power and the property of phosphorescence.

III. Polypifera, or polype-bearing animals. This includes the beings commonly termed *Zoophytes*, or Animal-Plants, on account of the resemblance in their mode of growth to that of Vegetables. Although the various forms of Corals, Madrepores, &c., which belong to this group, are themselves of an irregular form, the individual polypes (as already remarked § 991) possess the regular radiated conformation. And, as many species of polypes live separately, it is obvious that we should look to these, and not to the structures which they form, for the character of the Class; and to *their* varieties, for the characters of its subdivisions.

998. In the higher species of all these groups, which possess sufficient firmness and definiteness of structure to allow of a nervous system being detected, its form is found to correspond with the characteristic disposition of other organs. It consists of a circular filament surrounding the mouth, on which are a number of *ganglia* (or distinct centres of nervous action) usually equal to that of the segments of the body, and disposed at regular intervals. From these, diverging filaments are sent off, which are distributed to the various organs with great regularity. From this arrangement of the nervous system, the term *Cyclo-neura* (circular-nerved) has been applied to this division of the Animal kingdom, and is sufficiently characteristic of it.

999. Besides these classes, there are two others, in which neither nervous system nor radiated structure can be detected; but which must, for the present at least, be referred to the same group, although not possessing the radiated structure.

IV. Porifera, or animals whose surface is covered with *pores*. This group comprehends the Sponge tribe, and may be considered as intermediate between Polypifera and Plants.

V. Polygastrica, or many-stomached animals. This name has been given to the lower of the two groups into which, since the researches of Ehrenberg, the Infusorial Animalcules have been divided. It is believed by that Naturalist, that they possess a large number of separate digestive cavities, with distinct

walls, opening from an intestinal tube which connects them all. Much doubt yet exists on this subject, however; and until their real structure has been more fully determined, their place in the Animal kingdom cannot be satisfactorily assigned. No traces of a nervous system can be discovered even in the most highly-organised among them, by which this question could be set at rest. We shall associate them with the Radiated classes, on account of the general simplicity of their structure.

CHAPTER XXII.

OF THE CLASS OF ECHINODERMATA.

1000. This Class is unquestionably to be regarded as the highest, in point of complexity of structure, among those which constitute the Radiated division of the Animal Kingdom. It is characterized by the very regular disposition of parts round a common centre, which is found in nearly all the animals composing it, and which is never departed from in any remarkable degree; but chiefly by the hard integument, beset with spines or prickles, from which its name is derived, and which may be regarded as its chief external mark. This character, however, is not presented by all the species, which, on account of the general similarity of their organisation, are associated in the group;* but it is decidedly absent only in those, which evidently constitute links of transition towards other divisions of the animal kingdom. In no being is the radiated form more distinctly marked, than in the *Asterias* or Star-fish (Fig. 606), which is one of the best known species of this Class. And it exists not only in its external aspect, but in the arrangement of its internal organs, which are all disposed with perfect regularity around a common centre. In the *Echinus* or Sea-Urchin (Fig. 604), it is equally manifested in the arrangement of the plates which form its nearly globular shell (commonly termed *sea-egg*); but the more highly-organised condition of the digestive apparatus prevents the radial symmetry from being equally shown in the internal viscera. In the *Holothuria* (Fig. 608), it is still preserved in the circular form of the body, and in the disposition of the appendages around the mouth; although the

* The tubular feet hereafter to be described (§ 1006) are more universally present than the spines; hence it has been proposed to designate the Class *Cirrhodermata*.

globular shape of the Echinus gives place to a more prolonged form, which, in some species, even approaches to that of the Vermiform tribes (Fig. 609.).

1001. The three genera just named may be taken as the types of three Orders, into which this group may be conveniently divided. Between these orders, the links of transition are so very gradual (being often afforded by fossil species when no recent forms supply them), and the general similarity of organisation with many important differences is so well marked, that the whole group may be regarded as eminently *natural.* These orders we shall now describe separately, commencing with the one which may be regarded as most characteristic of the class,—that, namely, which contains the Echinus and its allied forms.

ORDER I.—ECHINIDA.

1002. In the order Echinida, the whole body is inclosed within a hard shell, usually of globular form, which is made up of a number of polygonal plates. The structure of the shell is not analogous to that which is found among the Mollusca. Instead of being solid, it is extremely porous; and seems as if it were made up of *areolar* tissue (ANIM. PHYSIOL. § 24), consolidated by carbonate of lime. The same kind of structure is met with in the hard parts of the entire group.—In order that it may keep pace with the growth of the soft parts, it is necessary that the shell should be capable of enlargement, or that it should be periodically thrown off and renewed, like that of the Crab. The former plan is here adopted; and it is beautiful to observe how perfectly the plan by which it is carried into effect is adapted to the wants of this simply-organised animal. The soft parts being, as it were, boxed up within the shell, it is obvious that a mere addition to the edges which surround its openings (such as takes place in the Mollusca), would rather complete its inclosure than add to the interior space. But by the regular addition of new matter to the edges of *each* plate, the

equable enlargement of the whole is provided for, and room is also made for the addition of new plates around the superior orifice. From the recent observations of Agassiz it appears that these new plates are developed according to a *spiral* arrangement; that is, a whole circle is not formed simultaneously; but the new plates at the top of the several rows are added in succession. This is an interesting fact, as showing a striking analogy to the growth of the leaves, and parts of the flower, in Plants. (See § 987, and VEGET. PHYSIOL. § 302.)

1003. The shell is covered in the living state by a membrane, which is sometimes very delicate, sometimes thick and spongy. This unites the bases of all the spines, and communicates with the interior of the shell by delicate processes, which pass between the adjacent edges of the plates; it is by these processes that the new material is secreted, which adds to the dimensions of each, and thus increases the capacity of the shell. Upon looking to the part of the shell which surrounds the superior orifice, it is seen that the plates are there less fully developed than they are below; their edges are not in such firm contact; and the tubercles to which the spines are attached have often scarcely

FIG. 604.—SHELL OF ECHINUS, OR SEA-URCHIN; on the right side, covered with spines; on the left the spines removed.

made their appearance. The enveloping membrane at this part,

in the living state, is softer and more spongy than in the lower portion; and it is in its substance that the first deposition of calcareous matter takes place, which constitutes the origin of a new plate. A careful examination of a specimen in progress of growth will show plates in all stages of development, from the thin calcareous scale on which no rudiment of spines can be seen, to the solid plate furnished with bold projections, to which are attached spines several inches long. The structure and origin of these spines will be presently described.

1004. The shell of the Echinida is covered in the living state by *spines*, which are sometimes very short and delicate, in other instances long and slender, and in many species of moderate length and considerable massiveness. These spines are attached to *tubercles* upon the surface of the shell, which are usually large in proportion to the size of the organs they support. The tubercles do not cover the whole surface, however; but they are disposed in regular rows from one opening of the shell to the other; and the plates from which they are developed are called *tubercular* plates. Between the bands of tubercles there are others almost destitute of these prominences; and the pieces of the shell composing them are termed *ambulacral* plates. These plates are usually not altogether destitute of tubercles; but the tubercles, as well as the spines which they bear, are very small in proportion to the same parts on the other series. The ambulacral plates are perforated by a large number of very minute orifices, through which delicate membranous tubes are put forth; these assist the animal in walking, or seizing its prey, in the manner to be presently described.

1005. The spines are united to the shell by the general enveloping membrane, which attaches itself round their bases; this membrane seems to have the power of contracting in all directions, as if it were composed of muscular fibre; and in this manner the spines are caused to move towards any required point,—their cup-like bases working upon the tubercles, in the manner of a ball-and-socket joint. In the *Cidaris*, which may be regarded as the most perfect of the Echinida, the spines are also attached by a round ligament (exactly like that of the hip-

joint in Man), which is inserted into a little depression at the top of the tubercle, and also into a small hollow in the bottom of the cup. In this manner great freedom of motion is preserved; and that degree of strength is added, which is required for the vigorous actions performed by the solid massive spines of this animal. The general enveloping membrane serves not only for the movement of the spines, but also for their nutrition. During the formation of the plates, as just now described, they shoot out from its surface like horns from the head of a stag. They remain covered, however, by delicate prolongations of the living membrane; and by these new layers are deposited, one around the other, so that the diameter and the length of the spine are increased at the same time. The structure of the spines corresponds with that of the shell; and it is remarkable for the exquisite beauty and regularity of its arrangement, as is seen when a very thin transverse section is placed under the Microscope.—The degree in which the spines are employed as organs of locomotion, or for other purposes, will vary, of course, with their size and strength. In the *Cidaris*, they seem to act as so many legs; and they are also used for excavating hollows in the sand, upon which the animal lies. In many of the *Echini*, they would appear too slender and fragile to support the weight of the body; but it is to be remembered that, when it is immersed in water, the pressure upon them will be very small. In some, however, they are broad and flat; and enlarge towards their extremities, instead of tapering to a point; the animals possessing these can move themselves in any direction by means of them, even on land. In the *Scutella*, the spines are extremely minute, but, at the same time, vastly increased in number; each of them is as perfectly organised, and its motions as much governed by the animal, as when they are fewer and larger; and by means of their combined action, the animal can speedily bury itself in the sand, for the purpose either of procuring food or of escaping from its enemies.

1006. In many of the Echinida, however, the chief locomotive organs are of a character entirely different. From the openings in the ambulacral plates, a number of very delicate

membranous tubes, each of them furnished with a sucker at its extremity, are capable of being projected. These tubes consist of two layers of muscular fibre, the outer one of which is circular, whilst the inner one is longitudinal. Each tube is connected with a little vesicle containing fluid, which is found within the shell, just behind the minute orifice through which the tube is projected. The several vesicles, which form five double rows (*ff*, Fig. 605), are connected by a set of vessels adapted to distend them with fluid; but every one seems to have a perfect command over its own tubular foot. When the vesicle propels fluid into it, the tube is projected to a considerable length; and the bands of muscular fibre which it possesses enable it to be turned in any direction, and to apply its sucker in the most advantageous manner. When the distension is withdrawn, by the relaxation of the walls of the vesicle, the longitudinal fibres contract, and the tube is shortened with considerable force; the water which it contained flowing back through the aperture of the shell into the vesicle behind. In many species this apparatus appears to afford the principal means both of locomotion and of the prehension of food. When several tubes are projected in any particular direction, and their suckers are attached to a fixed point beyond, it is obvious that, if the tubes then contract, the whole body will be drawn towards that point. Appearing, as it will then do, to turn upon the spines, it is not remarkable that many observers should have regarded the spines as the real instruments of locomotion; since the transparency of the tubes will prevent their being observed, unless they are carefully looked for.

1007. The action of these tubular suckers may be well seen in the common *Asterias* or Star-fish; from the under side of whose arms they project in great numbers. If one of these animals be placed in a glass vessel of sea-water, it may be seen to climb up its sides by the use of this apparatus. One set of suckers is fixed, and the animal is drawn towards them by the contraction of their tubes; it then takes a fresh attachment by a set which were previously free; and thus the numerous feet are all employed, fixing and detaching themselves alternately,

so that the animal gradually ascends the smooth surface, as it would the face of a submarine rock. In the animals of this form, too, we have abundant evidence of the use of the tubular feet in conveying food to the mouth. If the Asterias were entirely dependent on the slight hold which it can take by bending its rays, many animals upon which it preys would easily escape; but in this beautiful apparatus of suckers at the extremities of the feet, is a provision for retaining with great force whatever has been once entrapped, and for carrying it towards the central mouth. In the *Echinus* these tubes are much longer, and would seem to act like the tentacula of the Polypes,—floating loosely in the water, ready to attach their suckers to any animal that in its active movements may cross the field which they command. When a single foot has gained an attachment, others are speedily brought to its assistance; and the unlucky victim is soon secured. That the Echini use their tubular feet for progression also, is evident from the fact that, if placed in a basin of water, they are not unfrequently found within a short time perambulating its margin.

1008. Besides these tubular feet, there exists another series of appendages, so remarkable in their character, that they have been supposed to be separate animals parasitic upon the Star-fish and Echinus, and have been described as such under the name of *Pedicellaria.* Each consists of a stem, bearing at its summit a sort of forceps of calcareous matter, not unlike a crab's claw, except that the two (sometimes three) blades are equal and similar. When the point of a fine needle is introduced between the blades, which are for the most part open in a fresh and vigorous specimen, they instantly close and grasp it with considerable force. The particular use of these prehensile organs is not evident. They are not confined to the neighbourhood of the mouth; but, where they exist at all (for it is not in every species that they are found), they are disposed over the greater part of the surface, often forming dense groups around the spines.

1009. In all the *Echinida* the alimentary canal forms a long tube, possessing two orifices. We shall presently find that the

relative position of these orifices undergoes important variations in the different species. The intestinal tube usually makes about

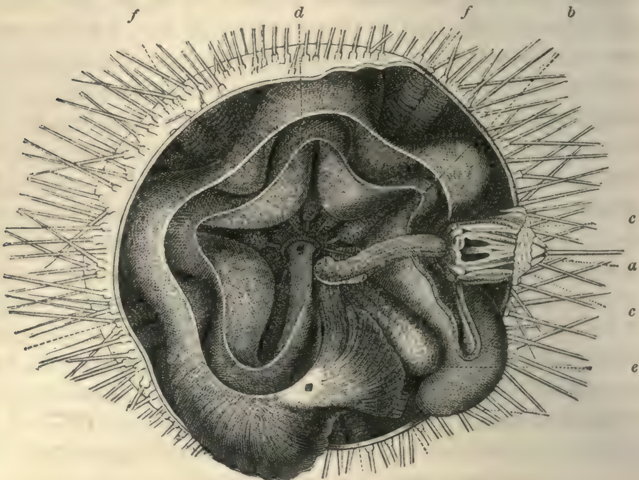


FIG. 605.—ANATOMY OF ECHINUS : *a*, mouth, surrounded by the teeth and jaws, *c*, *c* ; *b*, œsophagus ; *s*, stomach, or first portion of the intestine ; *d*, intestinal tube ; *e*, ovary ; *f*, *f*, ambulacral vesicles ; *g*, *g*, shell.

two turns within the shell; and it is attached to its walls by a fold of the membrane that lines the general cavity. This membranous fold contains distinct blood-vessels, by which the nutritive matter seems to be absorbed from the digestive cavity; and these blood-vessels form part of a complex system, by which the absorbed fluid is distributed over the whole body. We have in these animals, too, a distinct provision for the aeration of their fluid, by its exposure to a constantly-renewed layer of water. The whole cavity of the shell, except the portion occupied by the intestinal tube and its appendages, seems to be one great respiratory chamber. Water is admitted to it from without; and its lining membrane, on which the blood-vessels are minutely distributed, is covered with cilia, by the vibrations of which the fluid covering its surface is continually renewed, and the blood thus obtains a constant supply of oxygen from the

atmospheric air diffused through the waters of the ocean. The fluid is introduced into the cavity by ten respiratory tubes, which are placed around the mouth, and which bear a strong resemblance to the tentacula of the Sea-Anemone (Fig. 617). In the neighbourhood of the other termination of the alimentary tube are situated the ovaries, which open by separate orifices around the vent, just as do those of the Medusa around the single aperture of its stomach. These ovaries periodically enlarge to a considerable size; and in some species they are used as food, being termed the roe of the Sea-egg. In ancient Rome these parts of the Echini constituted a favourite dish at the tables of the great. It is not yet satisfactorily known, what degree of development the germs acquire, before quitting the parent.

1010. Many of the animals of this group are provided with a very complex masticating apparatus, consisting of five hard and sharp teeth, which are put in motion by a powerful set of muscles; these take their origin chiefly from five plates which project around the mouth into the cavity of the shell. The teeth work in bony sockets or jaws, which, when fixed together in their natural positions, form a five-sided conical mass (Fig. 605, *c*, *c*), aptly enough compared by Aristotle to a lantern, and frequently described by modern writers under the name of the "lantern of Aristotle." This complex machine consists of twenty-five pieces, moved by thirty-five muscles. It would seem to constitute a very powerful mill, in which the food is speedily reduced to fragments. Regarding the nature of their aliment, however, there is still some uncertainty; but there seems reason to believe, that small Crustacea and Mollusca constitute their chief food; but it is not improbable that, like others of the class, they are omnivorous, and can digest almost any organic matter that comes within their reach.

1011. The two most important genera of this Order are the *Cidaris* and the *Echinus*. The former is usually regarded as the most highly organised of the entire class; its spines being proportionally few and powerful, and being connected with their tubercles by a mode of attachment superadded to those which we find elsewhere (§ 1005). The *Echinus*, however, is the best

known of these genera, in consequence of its more extensive geographical distribution, and its abundance in the places it frequents. One species, found on the coast of Ireland, has the power of excavating for itself hollows in the limestone rock on which it lies; but by what means it does so is uncertain.—In the *Clypeaster* and *Scutella*, the shell is more or less flattened; and is sometimes divided by vertical partitions, so as in some degree to resemble a Star-fish. At the same time, the vent leaves its central position on the upper surface, and approaches the mouth, which still retains its central position below. In the *Spatangus*, or Heart-Urchin, common on many of our sandy shores, the radiated form is considerably departed from.—The shell, instead of being round, is oval; and it is often much prolonged in one direction, so that the radial disposition of its parts gives place to a bi-lateral symmetry. We here find neither the mouth nor the vent occupying a central position. Of the habits of the *Spatangi* little is known. They are almost always found buried in the sand; and their alimentary canal is filled with the same substance, in which they seem to find enough nutriment, composed probably of the minute animals mingled with it. As they are entirely destitute of teeth, and seem unable to bring their suckers into proximity with the mouth, they must derive their nourishment from the chance-supplies, which the substances in contact with their mouths may furnish. But their whole organisation is adapted to this mode of existence; as much as the more complex structure of the *Cidarites* is to the life, which *they* are intended to lead. Yet it is difficult to imagine how, with so little power either of locomotion or prehension, they can obtain the necessary amount of aliment.

Order II.—STELLERIDA.

1012. In this Order, of which the common *Asterias*, or Star-fish, may be taken as the type, we approach in a certain degree to the inferior forms of Radiata, Instead of the complete digestive apparatus, with two orifices, which we have seen in the

Echinida, we find a stomach only, with a single aperture, like that of the *Actinia* (§ 1057). This stomach has a distinctly radi-

FIG. 606.—ASTERIAS, OR STAR-FISH.

ated form. In the *Asterias* it occupies the centre of the body, and prolongations of it extend into the rays. The side of the body on which the mouth is situated, is always termed the *lower* surface; as the Star-fish and its allies generally live in this apparently-inverted position. The body and rays of the Stellerida are composed, like the spheroidal shell of the Echinida, of calcareous plates joined together.—The upper surface is usually covered with short spines, moving upon small tubercles, and connected by the general integument, as in the Echinus. It is on the lower surface only, and in the central line of each ray, that we find the ambulacral plates. The tubular feet are very numerous, though short, in the Star-fish; but much fewer in some other forms belonging to the Order. They are connected, as in the *Echinus*, with a tubular apparatus, which enables the animal to project them either together or separately; and this

apparatus (by which water is introduced into the body from without) seems to be the principal means of respiration enjoyed by the animal. The ovaria are disposed in a radiated form around the mouth; and they are found to be turgid in the spring and the commencement of the summer. Their spawn is thrown out upon sandy shores, where it is exposed to the action of the sun. It has not, however, been properly examined; nor has the mode of development of the young Star-fish been studied.

1013. The mouth of the *Asteriæ* opens at once into the stomach; it is unprovided with teeth; and the digestive secretions appear to constitute the only means possessed by the animal of reducing its food. There is considerable variety in this group, as to the number of rays, the proportion which they bear to the central disk, and the degree in which the stomach is continued into them. Some are so little divided at the edges, that in external form they approach the *Clypeasters* (§ 1011); whilst in others the disk seems almost absent, the animal being, as it were, *all rays*. In general organisation, however, there is a pretty close correspondence throughout.—The *Asteriæ* appear to enjoy a considerable amount of locomotive power. Their rays are very flexible, so that they can be drawn up towards the mouth, or moved from side to side towards each other, so as to give the animal the power of insinuating itself through narrow apertures. The rays appear to be principally moved by the general integument, which is thick and contractile. Small red points have been observed at their extremities in some species, which, from their connection with the nervous cord of each ray, and from their analogy with the eyes of other Invertebrata, are believed to be visual organs. This belief is strengthened by the observation of Professor Forbes, that the spines are disposed around them in a peculiar circular mode, so that they may be closed over these organs for their protection, or may diverge for their most extended employment. The same gentleman has remarked that these animals appear to take cognisance of objects of food placed at a little distance from them; and that, in their movements from place to place, they seem to be aware of obstacles in their direct

path, and to go out of their way to avoid them. It has been remarked also that, when all their feet are protruded, they will suddenly retract them, if any substance be brought in close proximity to them, but without touching them.

1014. Notwithstanding their possession of this amount of perceptive power, however, they do not seem to be very susceptible to painful impressions. If severe mutilations be performed whilst the animal is in a state of activity, it does not appear conscious of them, but continues its movements as before. The suckers in the neighbourhood of the injured part are retracted; but the others, even in the same ray, continue their actions, as if unaffected by the sense of injury. Of the extent to which reproduction of parts may take place after such mutilations, details have already been given.—The *Asteriæ* are animals of great voracity. Like the Actiniæ, they seem to be always gaping, as it were, for food; and to swallow whatever falls in their way. The mouth is extremely dilatable, so that it can admit large shell-fish and Crustacea, as well as small fishes, and fragments of larger bodies which may be cast upon the shore. Like the Sea-Anemone, they disgorge the undigestible parts by the same orifice; and they seem also possessed of the power of partially *everting* their stomachs, or turning them inside-out, so that the lining membrane projects through the mouth. Indeed it is in this condition that they frequently lie in wait for their prey; the protruded portion being wrapped round the object, and then drawn in. It seems to be by some means of this kind, that the Asteriæ are able to destroy and digest Oysters and Mussels, without drawing their bodies from the shell.

1015. In the *Ophiuræ* we find a more distinct central disk than in the Asteriæ; and to this the viscera are confined. It is furnished with arms, which are sometimes simple or undivided from one extremity to the other, and of a rounded tapering form, like a serpent's tail, as in the genus *Ophiuræ;* whilst in other genera, as the *Euryale*, they ramify minutely, dividing regularly into branches which again subdivide, so as to form a most complex series of appendages. These arms are all composed of jointed plates, like those of the *Asteriæ;* and they are possessed

of spines or scales. The *Ophiuræ* are much more active in their habits than are the Asteriæ. Their rays seem very flexible; and by the contraction of their envelope, they may be moved in all directions. Thus they are able to swim and to walk with considerable facility; as well as to exercise considerable power in obtaining their prey.

1016. To the Order Stellerida, also, belong the very interesting family of *Crinoïdea;* in which we find some important differences in organisation. This family, which was formerly much more abundant than at present, receives its name from the *lily-like* form which several of its members present (Fig. 607). The greater part of them, instead of moving freely where they will, are attached, during a portion or the whole of their lives, by a peduncle, or footstalk, to some solid body. And all of them seem to possess two orifices to the digestive cavity. Of this family the *Comatula* is the most abundant example; and as its organisation is better understood than that of any other genus, our notion of the character of the group is principally derived from it. In general form, the Comatula does not depart widely from some of the animals just described. The star-like aspect is still regularly preserved; and the mouth is in the centre of what must yet be regarded as the under surface of the body. The viscera are contained in the central disk, which is composed of numerous polygonal plates. The arms arising from this disk are five in number; but they speedily subdivide, each usually separating into four. These are composed of a number of calcareous pieces, solid and nearly cylindrical, which are inclosed in a living flesh of greater thickness than the integuments of the *Asteriæ.* Thus we have seen the rays, which in the Asteriæ contained the principal part of the animal, first deprived of the prolongation of the stomach, and then losing their cavity altogether, so as to become mere locomotive appendages to the central disk. To the skeleton of the arms, we find that jointed lateral appendages, of a similar structure, are attached; and these also are clothed with the fleshy integument which secretes them. Between these lateral appendages is a slight furrow, occupied by papillæ, which are furnished with vibratile cilia; and it appears

to be principally by the action of these cilia, that food is brought towards the mouth. Although the digestive cavity has two orifices, it is not constructed upon the plan of that of the *Echinida*. There is no separate alimentary canal ; but only a stomach like that of the *Asteriæ*, with a short tubular prolongation, of which the orifice projects between the mouth and the side of the disk. (This projecting orifice, which is very evident in the Encrinites, has been commonly mistaken for the mouth, which is much less apparent.) The *Comatula* often attaches itself to sea-weeds, or other floating bodies ; and, bending its long arms in various directions, it presents a very elegant appearance. Sometimes it swims freely through the sea, by an undulating movement of these appendages ; and sometimes it employs a part of them for seizing its prey, whilst with the remainder it clings to rocks, corals, or other firm supports.

1017. Now if we imagine a *Comatula* turned with its mouth upwards, and the opposite surface of the disk prolonged into a five-sided stalk, the root of which should be attached to some solid body, we shall have the form of the *Pentacrinus*. With the animals of this tribe we are chiefly acquainted by their skeletons alone. Only two species are known to exist at the present time. One of these, the *Pentacrinus Europæus*, is found in the Bay of Cork ; the other, the *Pentacrinus caput Medusæ*, in the neighbourhood of the West India Islands. The former only has been observed in its living state ; and it is so minute, that the anatomical investigation of its structure is a matter of some difficulty. It appears, however, to correspond in every particular, except the attachment by a stem, with the *Comatula ;* and there appears good reason to regard it as, in fact, the young state of that animal. When arrived at its full growth, the disk and arms quit the stem, and pass the remaining term of their existence in a state of freedom. The *Pentacrinus caput Medusæ* is a much larger animal, and its skeleton presents a most beautiful and regular structure. The disk and arms are formed like those of the *Comatula ;* the latter are very numerous, and thickly set with the jointed lateral appendages. The stem is more than a foot long, and is composed of a large number of pieces similar to

those of the arms. From this stem there arise, at regular intervals, several *verticils*, or whorls, of secondary arms; which do not subdivide, and are destitute of lateral appendages. From what is known of the animal in its living condition, there can be no doubt that all these parts are covered with a fleshy integument, by which they are produced, and to which they owe their power of movement. This integument seems to dip down between each joint, and to form the connecting medium between the different pieces. As the base of the stem of the recent species has never been obtained, the mode by which the Pentacrinus attaches itself to solid bodies has never been clearly made out; but there is reason to believe, from the circumstances under which fossil remains are sometimes met with, that the animals of this genus are not permanently adherent to solid masses, but have the power of occasionally detaching themselves.

1018. In some of the fossil species, the subdivision and ramification of the arms is carried to a much greater extent, than in either of the recent forms of this tribe. The number of pieces in the skeleton thus becomes very large. In the *Pentacrinus Briareus*, it has been calculated that at least 100,000 exist, exclusively of the joints of the lateral appendages, which are probably more than 50,000 additional. As each joint was furnished with at least two bundles of muscular fibre, one for its contraction, the other for its extension, we have 300,000 such in the body of a single Pentacrinus—an amount of muscular apparatus far exceeding any that has been elsewhere observed in the Animal Creation. But it will be remarked that these parts are but repetitions of one another in structure, and that consequently their variety of actions must be very small; and, accordingly we find that the movements of this complex piece of mechanism are far less capable of being combined and adapted to a specific purpose, than those of a prehensile structure of higher organisation,—the hand of Man—with its twenty-seven bones and thirty-nine muscles. A repetition of similar parts always implies a low degree of organisation, as it indicates a very small amount of variety in the functions to be performed; and the approach towards a higher character is marked

by the modification of some of these for particular purposes—a *specialisation*, or setting-apart, for some object of a more important nature, than those general functions to which they all contribute. But the simple actions, which alone can be performed by the arms of the Pentacrinus, are all that it needs for the grasp of its food.

1019. The general structure of the *Encrinus*, of which no recent species exists, bears a close affinity with that of the *Pentacrinus.* The body and jointed stem exhibit rather a rounded than a pentagonal form; the latter is often destitute of secondary arms; and the principal branches do not ramify with the same minuteness as those of many Pentacrini, but rather resemble in their distribution those of the *Comatula.* The stalk is attached by a sort of spreading root, like that of many Corals; and we must therefore believe this tribe of Crinoïdea to have been entirely fixed.—Besides the Encrinus and Pentacrinus, there are many other extinct genera of Crinoïdea, which present a very beautiful series of forms, all referable to the same general type; but on these our limits forbid us to dwell.—In the recent species of Crinoïdea, one or two of the arms may occasionally be found, of much smaller size than the rest, and apparently in process of replacing others which have been accidentally lost. Among the fossil Crinoïdea, such instances are by no means rare.

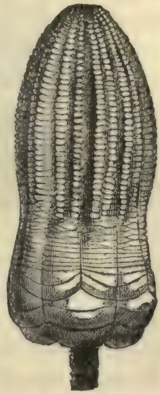


Fig. 607.—Encrinus.

Order III.—FISTULIDA.

1020. This Order may be regarded as connecting the *Echinida*, which may be considered as the types of the Class, with the Articulated series. In some respects it may be considered to present a higher grade of organisation than we elsewhere meet with among the Echinodermata; but this does not

entitle it to rank as the *typical* order of the class ; since its more elevated character is only obtained by its approach towards a very different type of organisation. This Order, which consists of the *Holothuria* and its allies, is known by the absence, except in a few instances, of the calcareous plates and spines of the *Echinida* and *Stellerida*. The skin is soft, and very distensible and contractile ; so that the size and form of the body are capable of great variation. The tubular feet, however, still exist.

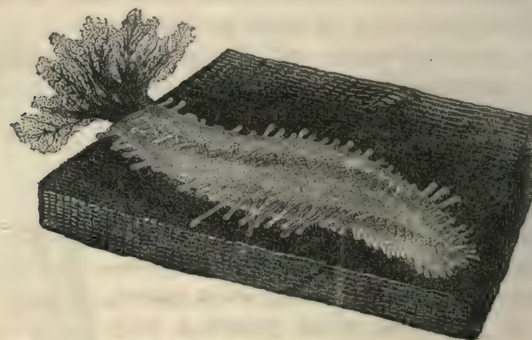


FIG. 608.—HOLOTHURIA.

They are sometimes arranged in distinct rows, stretching from one end of the body to the other ; and sometimes scattered irregularly over the surface. The general form of the body varies considerably in the different species. In some it is of a nearly globular shape, as in the *Echinus ;* not flattened at the poles, however, but prolonged at these points. In others it is still more lengthened, and presents slight transverse markings. And in the most aberrant species, the body exhibits an almost worm-like form ; being greatly prolonged, and contracted at intervals into distinct articulations. Nevertheless, in all these, the radiated type is evident in the conformation of the parts around the mouth. This is situated at the anterior extremity of the body, and is surrounded by appendages more or less ramified and fringed ; so that, on looking down upon these parts only, we might almost suppose them to belong to one of the *Stellerida*.

1021. Although the body is not furnished with any complete calcareous skeleton, we occasionally find a circle of plates around the mouth. These afford attachment to the muscles, which stretch along the entire surface of the body, and which are concerned in its alterations of form. The mouth does not lead to a distinct stomach ; but it is the commencement of a long alimentary tube, of nearly uniform diameter throughout ; which, after many convolutions, terminates at or near the opposite extremity of the body.—The *Holothuria* has the power of drawing inwards its tentacula, and of closing its mouth around them ; so that no appearance of them can be seen. It is probably by a movement of this kind that it swallows its food, which seems to consist of almost any kind of organised matter that falls in the way of the animal ; for the intestine is generally found distended with sand, in which may be detected the remains of corals, sea-weeds, and other marine substances.—There are some interesting points in the internal organisation of this group, which tend to show its relationship to the Articulata ; and their analogy to that group is further shown in their power of comparatively active locomotion. By the flexibility of their integument, and the muscular fibres with which it is furnished, they are able to swim and crawl with facility. Some of them frequent deep waters ; whilst others are found among rocks and floating sea-weeds, at no great distance from the shore.

1022. Near the Holothuria, we are probably to place the *Sipunculus* and its allies ; although the worm-like aspect of their bodies, and the entire absence of either prickles or tubular feet from the skin, would lead us to suppose them entirely different in character. In fact they constitute an extremely *aberrant* group

FIG. 609.—SIPUNCULUS.

—just such as the philosophic Naturalist might expect to find between classes formed upon types so different as the *Radiated* and *Articulated.* The mouth is not surrounded by radiating arms, as in the *Holothuriæ*, but it is armed, in many species, with a set of teeth arranged in a pentagonal form, like those of

the *Echinus*. In some, however, this is replaced by a sort of proboscis, which may be protruded or retracted like that of many Annelida (§ 835). So great a resemblance, in fact, do such animals bear to certain species which we find in this Class, that, until their structure has been more fully investigated, and the arrangement of their nervous system ascertained, it may be doubted whether their true place is not in it, rather than among the Echinodermata. Nothing can be imagined that is wanting to complete the connection between these two classes, which is established by means of this group. The *Sipunculi* are seldom found but on sandy shores. They excavate holes in the sand, in which they conceal themselves, occasionally protruding their heads from the orifice. They are much sought after by fishermen, who use them, like the common lob-worm (*Arenicola piscatorum*) whose habits are so similar, as baits for their hooks. Some of them attach stony particles to their skin, by a glutinous exudation, so as to cover it with a hard crust, resembling that formed by some Annelida (§ 840).

1023. In regard to the *Geographical* distribution of the Echinodermata, it may be stated generally, that all the families of this Class are represented in nearly every portion of the globe. As among other classes, however, so in this, it would appear that the largest species (especially of the *Comatula* and *Pentacrinus*) are found in tropical regions; but *Echini*, *Asteriæ*, and *Holothuriæ*, occur in plenty on our own coasts. Star-fish occasionally abound so much on the shores of France, as to be used for a profitable manure. We have no certain knowledge as to the animals which find in the Echinodermata their regular food. Of the *Stellerida*, Man makes no other use than that just stated; and of none of the *Echinida* does he eat any other part than the roe (§ 1009). The large use made of the *Holothuriæ* by Man, as a source of nutriment, is not generally understood. One species is collected and eaten by the poor inhabitants of the Neapolitan coast; but there is another which constitutes an important article, not only of consumption, but of regular traffic. Captain Flinders (1803) fell in with a fleet of Malay proas, near the Gulf of Carpentaria, on the north coast of New Holland; and

was informed that sixty proas, carrying one thousand men, had left Macassar two months before on an expedition to that coast, the object of which was the collection of *trepangs* for the Chinese market. The *trepang*, *bêche de mer*, or *sea-cucumber*, is no other than a *Holothuria*, which is extremely abundant on that coast; in shallow water, the animal may be taken up by the hand; in deeper water it is obtained either by diving or spearing. In order to preserve the edible portion of it, the body is split down one side, boiled, and pressed with a weight of stones, then dried in the sun and stowed away in bags. About a thousand of them make a *picol*, which is equivalent to 133lbs.; and 100 picols are a cargo for a proa. It is carried to Timor and sold to the Chinese, who meet them there; and when all the proas are assembled, the fleet returns to Macassar. It would seem that European traders have now become alive to the value of this traffic; for there are regular establishments in different parts of the Dangerous Archipelago, for those who go *bêche-de-mer-ing*, as the employment is commonly termed. After exhausting the supplies furnished by one island, they pass on to another, and usually complete their cargo within a few weeks. The quantity annually sent to China from Macassar, which is the principal market of the *trepang*, is usually about 7000 picols, or 416 tons; the price usually varying from 8 dollars a picol to 115, according to the quality. There is also a considerable export of trepang from Manilla to Canton. The *Sipunculus*, also, is used as an article of food in China and Japan.

1024. The *Geological* position of the different families of Echinodermata presents us with many points of great interest. No remains of any of them can be traced in the very oldest fossiliferous rocks; but, judging by the abundance of the skeletons of *Crinoïdea* in the limestones of the Transition series, the animals of that group must have been among the most numerous of the larger inhabitants of the ocean, at the time these strata were deposited. So abundant are they, indeed, that they may be almost said to constitute those thick and extensive beds of Transition limestone, which, from the wheel-like form of the separate joints of the Encrinite stems, is termed Entrochal

Marble. "The substance of this marble," says Dr. Buckland, "is often almost as entirely made up of the petrified bones of Encrinites, as a corn-rick is composed of straws. Man applies it to construct his palace, and adorn his sepulchre; but there are few who know, and fewer still who duly appreciate, the surprising fact, that much of this marble is composed of the skeletons of millions of organised beings, once endowed with life and susceptible of enjoyment, which, after performing the part that was for a while assigned to them in living nature, have contributed their remains towards the composition of the mountain masses of the earth." It cannot be deemed improbable that, of those forests of *Encrini* to which these depositions are principally owing, some grew on the sides of the Coral reefs from which other beds of limestone seem to have originated; and that the *debris* (or separate particles) of the reefs furnished the calcareous matter, by which their skeletons are held together. Fragments of Encrinites are also dispersed irregularly throughout all the deposits of the Transition period, intermixed with the remains of other contemporary marine animals. No other species of Echinodermata, however, as yet present themselves; and it is interesting to remark, that the *Crinoïdea* which so abound in the Transition epoch (more than thirty species being known) belonged, with one exception, to the *Encrinus* and other round-stemmed genera, and were therefore more unlike the existing forms of that family, than were those which we find at a later period. All these Crinoïdea, which continue to abound in the Mountain Limestone and other of the more ancient secondary rocks, become extinct when we arrive at the Lias; and are then replaced by the *Pentacrinus*. The stems of Encrinites compose extensive beds in the Carboniferous, as in the Transition series; and these are often found in the neighbourhood of those of a distinctly Coralline nature, so that the animals probably grew on the banks of such reefs as are now being elevated in the Southern Ocean, and which, if properly examined, might be found to support their living analogues. The joints of the Encrinite-stems often fall asunder when the connecting rock is not firm enough to hold them,—the animal membrane which

united them in the living state having long since decayed away. Their flat round form, and central perforation, have occasioned them to receive the name of Entrochi, or wheel-stones. They were formerly strung as beads for rosaries; and in the northern parts of Britain they still retain the appellation of St. Cuthbert's beads.

> "On a rock by Lindisfarn
> Saint Cuthbert sits, and toils to frame
> The sea-born beads that bear his name."

1025. The *Pentacrinus* first began to abound at the commencement of the Lias; and its remains present themselves in great numbers in that formation, and in the Oolite which succeeds it. From that period they diminish, and we gradually lose sight of this interesting group,—the few existing species serving, as it were, but to indicate the structure of those, which formerly occupied so important a rank among the inhabitants of the ocean.—As the Crinoïdea disappeared, the other Stellerida and Echinida took their place; and remains of these are met with in almost all marine strata, down to the present time,—being particularly abundant in the Chalk and Oolite.

CHAPTER XXIII.

OF THE CLASS OF ACALEPHÆ.

1026. THE animals composing the class ACALEPHÆ differ widely in external form, and frequently, also, in the arrangement of their organs; so that it is difficult to assign any character which shall be applicable to them all. Perhaps their most general point of agreement is the extreme softness of their tissues, and their free unattached condition: by the former they are distinguished from the Echinodermata; by the latter from the Polypifera. Although the radiated structure is well marked in the forms which we may regard as typical of this group (Fig. 610), yet it is so entirely obscured in others (Fig. 614), that, if they be regarded out of connection with the rest, their claim to a place in this division of the Animal Kingdom would be very doubtful. In general, however, it is not difficult to find links of transition, by which the radiated forms pass into those that are constructed apparently upon a different type; and, when this is the case, we should have no hesitation in uniting

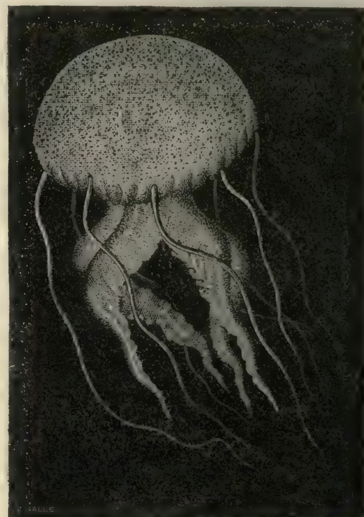


FIG. 610.—PELAGIA.

the latter under the same general denomination, since they agree in the peculiar character of the group as stated above, and cannot be received into others.

1027. The Acalephæ derive their name (which means *nettles*), from the stinging power which nearly all of them possess; and some of their common names, as "Sea-nettles," or "Stang-fishes," have the same origin. This stinging power appears due to a peculiar acrid secretion from the surface, which remains after the death of the animal, and may be communicated to substances which are placed in contact with it. They are also commonly denominated "jelly-fish," "sea-blubber," &c.; partly from their uncouth appearance when cast upon the shore; and partly from the extreme softness of their tissues, which melt away (as it were) when removed from the water. This delicacy of structure is common to the whole group. In the greater part, there is no hard support whatever; and the animals, when taken out of water, lose their form completely. In a few species, however, there is a very thin cartilaginous plate, which retains its form when dry. The substance of these animals consists of a tissue somewhat resembling cartilage (ANIM. PHYSIOL. § 45); but containing so little solid matter, that a *Medusa*, weighing several pounds when alive, is reduced almost to as many grains when dried. The fluid gradually drains away, leaving but a thin pellicle incrusting the surface on which the mass was placed.

1028. In most of all the Acalephæ, which possess a distinctly radiated form, the stomach or digestive cavity is central (Fig. 611). It usually opens by a single orifice, placed in the centre, and surrounded by tentacula; but there are several curious species (Fig. 612), in which there is no regular mouth; the food being taken in by a number of suckers, having minute orifices at their extremities. In all, however, it is remarkable, that the number 4 and its multiples may be almost constantly observed to govern the distribution of the organs. Although possessed of a certain degree of locomotive power, the movements of the Acalephæ are very feeble; they are carried about by the ocean currents, almost at their mercy; and many of them have the means of making the gentle breezes subservient to their

change of place in search of food. None of them, however, can endure a rough sea. Although in calm weather they float in countless myriads upon the surface, they sink, on the slightest disturbance of it, into the depths of the ocean. For the same reason, they prefer the open sea to the neighbourhood of the coast; and in fact to approach the land is almost fatal to them. They are often driven by the winds and currents which they cannot resist, against the hard shore, and there they are soon beaten to pieces by the waves; or they are left dry by the tide, which they have not the power of following, and speedily melt like the spangled hoar-frost beneath the sun-beam.

1029. The voyager in the open sea, however, often encounters whole fleets of these animals, extending, as far as the eye can reach, basking as it were in the sunshine that illumines the surface, and reflecting its rays with all the gorgeousness of the most brilliant iridescent hues. Most of the Acalephæ seem inclined thus to associate; and in tropical regions, where they exist in the greatest abundance, the voyager, after passing through a fleet of one species, will in a short time encounter an equally extensive collection of another kind. It is not by day only, however, that these animals delight the eye of the mariner. It is chiefly to them that the *phosphorescence* of the sea is due, which is occasionally observed on our own coasts, but only in a degree which affords a faint idea of the extraordinary nature of this phenomenon as it presents itself in warmer latitudes. The whole surface of the ocean displays a diffused luminosity, like that of the Milky-way on a clear night. The path of the ship is marked by a brilliant line of glowing light. The waves, as they gently curl over one another (this phenomenon is never seen with a *rough* sea), break into brilliant spangles. The oars of a boat rowing over them, seem dripping with pearls when raised from the water; and every stroke is marked with a new line of brightness. And amidst this general splendour, varied forms of more glowing lustre are seen to move—some like ribands of flame—some like globes of living fire—some gently gliding through the still ocean, others more rapidly moving just beneath its surface. Now, although other marine animals—such as the *Pennatula*

(Fig. 622) and other Polypifera, the *Pyrosoma* (§ 983) and other Tunicata—contribute to produce this dazzling effect, it is principally due to the various species belonging to the group we are now considering.

1030. The *diffused* luminosity is given by minute species; and on our own coasts it is principally due to the *Noctiluca*, a little animal much resembling a grain of boiled sago in size and appearance. The anatomy of this animal has not yet been satisfactorily investigated, notwithstanding its occasional abundance; and its true place in the Class has not been ascertained. It seems like a little granule of jelly, with a long stalk. This stalk appears to be a trunk or sucking-tube, by which the food is taken in; and it is capable of being extended, or drawn in, to a considerable degree. The luminous secretion appears in all instances to become more vivid, when the animal is alarmed or stimulated in any way. Hence the disturbance of the water, by the gentle curling of the waves over each other, or by their ripple on the shore, is marked by lines of increased brilliancy. The movement of a boat, and the stroke of the oars, will have the same effect. If the animals be washed over the sands, they continue to display their luminosity in a fainter degree for some time; but every footstep of a person who walks over them is studded with brilliant points. And if the hands be dipped in the water thus phosphorescent, and then rubbed together, they will be covered with luminous spots; which, when examined, are found to be occasioned by the phosphorescent glow of these delicately-formed little animals. There are few parts of the British coasts, where this phenomenon is not occasionally witnessed. It generally follows a continuance of some particular wind; but the direction required varies in different parts of our island. It is thus that we obtain a more accurate idea of the vast amount of animals composing this tribe, than we derive from any observations that can be made during the day. Their bodies are often so transparent, that they can scarcely be distinguished from the water through which they are diffused, except when displaying their phosphorescence. But when the whole surface of the ocean, as far as the eye can reach, is seen to exhibit a uniform luminosity, and this is ascertained to

be due to animals not larger that the head of a pin, in close apposition to each other,—the vast amount of organic life which ordinarily escapes our notice, can scarcely fail to strike us with astonishment, not unmingled with pleasure at the thought, that each of these little beings is passing a life of enjoyment, and is performing an allotted function in the great economy of Nature.

1031. The structure of a large proportion of the Acalephæ is not yet sufficiently understood to permit a very satisfactory arrangement of the Class; and we must be satisfied with a description of some of the principal forms which it includes.—The *Medusa* (Fig. 611) presents to the eye, when it is floating

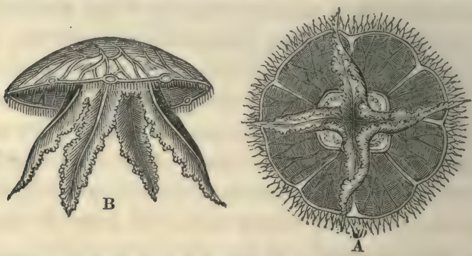


Fig. 611.—Medusa; A, under surface, showing the mouth in the centre, surrounded by the tentacula, and the ovarial chambers exterior to the origins of these; B, side view, showing the tentacula hanging down in their natural position.

in its native element, an umbrella-shaped disk, from beneath which hang down four tentacula or arms. The central part of the concave side of this disk is occupied by the stomach, in the middle of which is the mouth, opening downwards, and surrounded by four leaf-like tentacula. Around the stomach are four ovarial chambers, with separate orifices. These organs occupy the space inclosed, as it were, within the frame-work of the umbrella; but the delicate membranous disk projects considerably beyond them, and floats freely in the water. It appears to have some muscular power; for it is by its gentle undulations, which are performed with great regularity, that these animals are propelled through the ocean. This free portion of the disk is traversed by numerous canals, which are to be regarded as prolongations of the digestive cavity. Eight of these pass directly outwards, and terminate in a corresponding number

of orifices at the edge of the disk. But another set of eight subdivide and ramify, so as to form a sort of net-work of vessels, which appear to serve for the nutrition of the portion of the structure at a distance from the stomach, and also to expose the nutritive fluid to the aerating action of the surrounding water. The *Medusæ* often attain considerable size. It is said that their disks have been seen three or four feet in diameter; and that the animals have weighed as much as 60 lbs. It might be inferred from the extreme delicacy of their structure, that they are supported only on food most easily obtained; but this is by no means the case; for in their stomachs are found small Crustacea, Mollusca, and even Fishes. It would seem that their tentacula, like those of the Hydra, possess considerable muscular power; and that they are capable of drawing towards the mouth almost anything which comes within their reach. Even large Fishes are occasionally found entangled amongst them. Very probably their stinging power is of use in weakening the resistance of thei rprey.

1032. There are several Acalephæ, which resemble the *Medusæ* in general form, and especially in the possession of this umbrella-shaped disk, by the undulations of which they move through the water; but which yet differ from them in many important and curious points of organisation. Sometimes the mouth is prolonged into a sort of proboscis, formed, as it were, by the union of the bases of the tentacula, so as much to resemble the stalk of a mushroom. Sometimes the tentacula are of much smaller proportional size, and then we usually find a series of filaments hanging from the free margin of the mantle (Fig. 610). Occasionally the tentacula almost disappear, and then these filaments are largely and abundantly developed, and

FIG. 612.—RHIZOSTOMA.

probably replace them in function. The most curious modification, however, is that which is displayed to us in the *Rhizostoma* (Fig. 612), an animal bearing a close external resemblance to the Medusa. Here the central mouth is entirely absent; but the tentacula are channelled through their whole length, and their tubes open at their base into the stomach. At the free extremity, the tube of each subdivides and ramifies like the roots of a plant; terminating in a number of small suckers, in the centre of each of which there is a small pore. It has been shown, by placing one of these animals in a coloured fluid, that solid particles, if sufficiently minute, may enter these pores; but this species must either be nourished by extremely minute animalcules, or by imbibing the juices of other animals, upon which it fixes its suckers.

1033. According to Ehrenberg, a nervous circle may be detected surrounding the mouth in some animals of this group; and another, connected with the first, running round the margin of the disk. From the latter he states that filaments may be seen to pass to certain red spots upon the edge of the disk, which he imagines to be eyes. Upon this point, however, there is yet considerable doubt. The animals of this group appear very little sensitive to injurious impressions. They give no signs of feeling the deepest and most extensive wounds of their surface; and the movements of contraction and dilatation have been seen in parts of the disk almost separated from the rest, as well as in the entire animals when nearly two-thirds of their bulk had been lost by the draining of their fluids. In such instances, the movements may be re-excited after they have ceased, by friction and by punctures of the fibrous substance, just like those of the heart and alimentary canal in the higher animals; and they would seem to be of an equally involuntary character.

1034. Some very curious discoveries have been recently made, in regard to the development of the embryo in the Medusa and its allies. The eggs are transferred, when they leave the ovarial chambers, into certain *marsupial* sacs or pouches, on the under side of the arms. There they undergo the early stages of their development, and then issue forth in the condition of

Animalcules, freely moving by the *cilia* with which they are provided at their edges.—After a time they fix themselves at one extremity; and gradually become converted into Polype-like animals. In this state they remain several months, obtaining their food by means of long slender tentacula; and each of these polype-like bodies then separates, by transverse division, into from ten to fifteen young Medusæ, which gradually acquire the form of the parent.

1035. Another most interesting form is the little *Cydippe* (formerly called *Beroe*), which is often abundant on our own coasts. This animal is of a nearly globular form, sometimes a little elongated at the two extremities, and about three-fourths of an inch in length. It is composed of a delicate jelly-like substance, strengthened by eight bands of somewhat firmer texture, which run like meridian lines from pole to pole. These bands are covered with rows of large *cilia*, arranged side by side, so as to form narrow plates of a fin-like character. There are, in the most common species, from three to seven cilia in each row; and about twenty rows on each ridge. The whole ridge is not unlike the paddle-wheel of a steam-boat; but the motion is given by the vibration of the separate floats, and not by the revolution of the whole. Over these floats the animal has evidently complete control; it can retard or stop their movements at pleasure; and arrest the play of one, two, or more rows whilst the remainder continue in rapid vibration. By these means it is capable of swimming through the water with considerable activity, and of changing its course at will. The animals themselves are of a bright faintly-blue aspect; and the cilia present vivid iridescent hues when in motion. The mouth is situated at one of the poles of the globe, and it is always directed forward when the animal is in motion. It is a wide entrance to the short œsophagus, which terminates in the stomach; it can be closed by the animal when irritated; but when

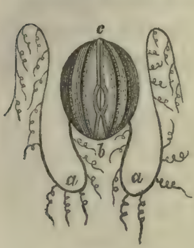


Fig. 613.—Beroe.
a, a, tentacula; *b*, mouth, *c*, termination of intestine.

freely swimming through the water, it is always widely dilated. From the stomach, there passes a narrow straight intestine, which terminates at the opposite extremity of the body. When the animal is in active movement, therefore, a continual stream of fluid will enter its mouth, and will pass out again behind ; and from the minute particles contained in this fluid, its nourishment is probably in part derived.

1036. These apparently powerless little animals feed, however, like other Acalephæ, upon species of much higher organisation and firmer texture ; and they are provided with similar means of obtaining them. From the posterior part of the body arise two filaments, which are many times its own length. These are provided with lateral filaments, which arise at regular intervals from one side along their whole course, and are spirally coiled like the tendrils of a pea. The principal filaments do not arise from the surface of the body, however, but from the bottom of two deep cavities extending into its interior. Into these cavities the main filaments with their appendages can be entirely retracted. The lateral fibrils seem to contract spirally towards the longitudinal filaments ; and the latter are drawn by irregular contractions into the cavity, so as to be entirely concealed. When the animal wishes to put them forth, it seems to contract the cavity, and the filaments are jerked forth, as it were, not simultaneously, but first on one side and then on the other. When the main filaments have been ejected from the body, the little tendrils begin to uncoil. When one of these beautiful little animals is placed in a vessel of sea-water, it sometimes remains at the bottom, projecting its long filaments upwards. At other times it darts upwards with great velocity, drawing its long filaments after it, retracting and extending them alternately. Not unfrequently it remains for some time at the top of the water ; and, when it wishes to descend, it turns over, drawing up its filaments suddenly, and then swims, mouth-downwards, to the bottom of the vessel.

1037. The *Cestum Veneris*, or Girdle of Venus, an Acalepha belonging to the same group with the preceding, is a flat riband-shaped animal, which sometimes attains the length of five or six

feet, whilst its breadth is not more than as many inches. At first sight, the form of this species might forbid us from ranking it near the *Cydippe.* When we examine its structure, however, we find that there is a much greater real correspondence than would have been suspected. The mouth is placed, not at one extremity, but at the centre of one of the sides. The alimentary tube passes straight across the body,* and terminates on the opposite side ; the digestive organs closely resembling those of the Cydippe. The uniformly gelatinous consistence of the whole animal, as well as this peculiar conformation of its alimentary canal, forbid our ranking it in the Articulated series ; to which its prolonged form might have led us to refer it, if the mouth had been placed at one extremity, and the alimentary tube had traversed its length. The edges of both sides are fringed with cilia from one end to the other ; and it appears to be by the vibrations of these cilia, rather than by any movement of the body itself, that it is propelled through the water. As in the *Cydippe*, a system of vessels absorbs the nutritious fluid produced by the actions of the digestive apparatus, and conveys it to the remainder of the structure, here so remote. And here, also, we find a part of these vessels running under the ridges bearing the cilia, as if to expose the fluid they convey to a stratum of water continually renewed by the ciliary action. We might then regard this animal as a *Cydippe*, flattened and extended in a lateral direction ; and many very interesting forms of transition have been discovered, which show that this view of its structure is the true one.

1038. The group of *Hydrostatic* Acalephæ, is characterised by the presence of one or more large air-sacs, by which great buoyancy is given to these beautiful animals. It would appear that they have considerable power over these organs ; either forcing out the air contained in them, or compressing it into a much smaller compass, when they wish to sink ; and distending the sac by some unknown means when they desire to rise. We seldom meet with anything like radial symmetry in this group. The forms of the species are extremely variable and irregular ; but there is usually a correspondence between the two

sides of each individual. A well-known example of this group is the *Physalus utriculus*, commonly termed the Portuguese Man-of-war. This possesses a single large air-sac, beneath which the digestive apparatus is disposed; and the sac is surmounted by a sort of crest (*b*), which possesses a greater degree of firmness than the rest of the structure, and is elevated entirely above the water, when the animal is floating at the surface; so that when exposed to the influence of the gentle breeze, the animal is wafted by its means from place to place.

FIG. 614.—PHYSALUS.

The air-sac itself possesses considerable muscular power. It is provided with two orifices (*a*, *c*), one at each extremity, through both of which air is forced out when the bag is compressed by the hand; each of these orifices is provided with a little circular muscle, which usually keeps them closed, but which allows of their dilatation during the continuance of the outward flow of air. It is not improbable that the alteration in the specific gravity of this animal required for its sinking in water, is effected partly by the expulsion of air in this manner, and partly by the compression of the remainder. No definite stomach can be found beneath. There is a mass of short flask-shaped appendages, which hang down from the under side of the air-sac, and are terminated by suckers, with an orifice in each. Whilst the lower surface of the air-sac is not itself above six inches from one end to the other, the tentacula sometimes hang down like fishing lines, to an extent of sixteen or even eighteen feet. They generally possess an active stinging power, and are also very contractile, so that they are able to draw the prey which they have attacked towards their point of origin. It would seem that the short suckers are attached to the bodies of animals thus entrapped; and that the *Physalus* derives its nourishment by imbibing their juices through the pores of these numerous cirrhi. This animal is one of those most commonly observed by voyagers, sailing in fleets upon the calm surface of the ocean, and

disappearing with great rapidity when alarmed by the roughness of the waves.

1039. Our account of the Acalephæ cannot be better summed up than in the words of M. Peron:—"Among the animals of this family," he observes, "we find the most important functions of life performed in bodies which offer to the eye little more than a mass of jelly. They grow frequently to a large size, so as to measure several feet in diameter; and yet we cannot always determine what are their organs of nutrition. They move with rapidity, and continue their motions for a long time; and yet we cannot always satisfactorily demonstrate their muscular system. Their secretions are frequently very abundant, and yet the secreting organs remain to be discovered. They seem to be too weak to seize any vigorous animal, and yet fishes are sometimes their prey. Their delicate stomachs appear to be wholly incapable of acting upon such food; and yet it is digested within a very short time. Most of them shine at night with great brilliancy, and yet we know little or nothing of the nature of the agent which produces so remarkable an effect, or of the organs by which it is elaborated. And, lastly, many of them sting the hand which touches them; but how, or by what means, they do so, remains a mystery."

CHAPTER XXIV.

OF THE CLASS OF POLYPIFERA.

1040. No doubt can now exist of the Animal character of the beings composing this class; although the Plant-like form which many of them present, deceived the Naturalists of former days, as it does the uninformed observer at the present time, into the belief of their Vegetable nature. In the works of the older Botanists, the *zoophytes* (a term which may be advantageously restricted to this class), whether hard and stony, or flexible and horny, were arranged and described with Sea-weeds and Mosses, without any misgivings as to to the propriety of doing so. So far was this theory carried, that the Sea-Anemone was described as a veritable flower; and Count Marsigli, who detected the existence of analogous beings in coral and madrepore, spoke of them as the *blossoms* of these stony plants. It is now just a century since the doctrine of their Animal character, now universally admitted, was received with any degree of favour by the learned.

1041. It is only of late, however, that this class has been carefully investigated and well understood. A large proportion of those compound structures, which are known as *Coral*, *Madrepore*, &c., come under the inspection of Naturalists only in their dry state, stripped of all that characterises the living animal. Hence their classification has, until recently, been founded solely upon the characters presented by these structures. Some of them are massive and stony; others of more delicate conformation, and of horny consistence. Some of them serve as a central axis or stem, which is clothed with the living flesh; others form a tube, which sheaths the softer tissues, and this variety is found to exist among both the stony corals or *lithophytes*, and the horny flexible corals or *keratophytes*. Moreover

there are some polypes which do not form associations, and which deposit no hard skeleton, but which are closely allied in general structure to those that do; such are the *Hydra* or fresh-water Polype (Fig. 615), and the *Actinia* or Sea-Anemone (Fig. 617). In the classification founded only upon the characters of the compound masses, therefore, the *naked* Polypes (as they were termed) were associated into a separate order. By this method —as by any which depend upon a single set of characters, and are therefore *artificial*—beings the most dissimilar were associated together; and those which were really allied in the structure of the individuals, were separated, because there was a dissimilarity in the form of the compound masses.

1042. Bearing in mind the resemblance formerly pointed out, between one of the compound Polypifera and a Vegetable structure, in regard to the aggregation of distinct individuals into one common life (§ 986), we shall at once perceive the necessity of looking for the characters which are to serve for the classification of this group, not in the degree of density of the stem, or in the arrangement of its branches, but in the structure of the separate Polypes. The Botanist well knows that in the leaves and flowers he must find the materials for *his* classification; and not in the degree of firmness of the wood, or the mode of growth exhibited by the whole structure, which are liable to vary so much with age and circumstances, and to differ so completely in species which are really in close alliance. In this manner, the class of POLYPIFERA may be divided into four Orders, characterised by four distinct kinds of structure. Each of these Orders contains Polypes in various degrees of association;—some living solitarily;—some existing in societies;—some united by a connecting flesh;—and some having a common circulation of fluid amongst them. Each, therefore, contains some which form a solid structure, and others which are destitute of it.—The differences between these Orders are such, that it will be desirable to give a detailed account of each separately.

Order I.—HYDROIDA.

1043. The *Hydra*, to which reference has been made as the type of one of the divisions of the Polypifera, is a minute animal, common in stagnant pools of water, where numbers are often found clustering upon aquatic plants, or other floating bodies. Although most of the species prefer fresh water, some are occasionally found at sea. These curious little creatures possess an organisation which appears very simple, and so it has long been considered; but recent improvements in the power of the microscope have enabled its structure to be more fully analysed, and have revealed (in this as in every other instance) details that were previously unsuspected. The *Hydra viridis*, or Green Polype, and the *Hydra fusca*, or Brown Polype, are the two best known species; and to these our description will chiefly apply. The body of the Hydra consists of a simple bag, or sac, constituting the stomach of the animal, and capable of varying its form and dimensions to a very remarkable extent. In the largest species it sometimes attains the length of an inch, when stretched out in a cylindrical form; whilst it will appear, in its contracted state, as a small globe of scarcely perceptible dimensions. At the upper end of this digestive sac is an opening, which may be regarded as the mouth of the animal; and round this are arranged a certain number of *tentacula*, or long flexible arms, which diverge from each other like the spokes of a wheel. If we look at the mouth of the *Hydra* from above, therefore, we shall at once perceive the claim of this animal to a place among the Radiated Sub-Kingdom. The arms vary in number; being usually from six

Fig. 615.—Hydra.

to ten. They vary also in dimension; not exceeding in the former species the length of the body; whilst in the latter they often extend themselves to as much as seven or eight inches, still being able to contract themselves down to minute tubercles or knobs projecting around the mouth. The animal, in its general aspect, is thus seen to bear a close resemblance to the Cuttle-fish;* and in the peculiar organisation of its arms for the seizure of prey, this resemblance, as we shall presently see, is extremely remarkable. In fact, this little Polype may be regarded as one of those *sketches* or *fore-shadowings* of higher forms, which we occasionally meet with in the lowest groups.

1044. The arms are destitute of cilia; and this is an important character, by which all the Polypes of the Hydra-form kind may be at once distinguished from those of a higher group (§ 1095). They are thickly set, however, with minute bristles; besides which, a number of little wart-like processes may be observed, from whose summit sharp and firm spines are occasionally protruded, by which a very firm hold is taken of whatever substance is embraced by the animal. The mechanism by which these are pushed out of their sheath is very curious. Each spine is mounted upon the summit of a small vesicle, which is capable of expanding and contracting within an envelope, that embraces the whole apparatus. When at rest, this vesicle lies at the bottom of the including sac, and the spine is drawn entirely within it; but, when the animal lays hold of any object with one or more of its arms, the vesicle is distended by some unseen means, and protrudes the spine which is seated upon it.

1045. When in search of prey, the Hydra permits its arms to float loosely through the water. It is rather curious that so inactive a creature as this should principally depend for its food on the minute Crustacea and aquatic Worms, whose rapid movements would seem to place them beyond its reach. By lying in wait, however, with its arms thus disposed, the Polype soon

* It was this resemblance which caused Réaumur to give to the Hydra the name of ***Polypi***; the polypi of the ancients being the animals now included in the genus ***Octopus*** of the Cephalopoda.

succeeds in obtaining its supply; for if, in their active course, any of these animals should but touch one of the tentacula, its doom is sealed;—it is immediately seized by it;—other arms are soon coiled round it;—and the unfortunate victim is speedily conveyed to the mouth. It has been noticed that, if held for a little time in the arms without being swallowed, soft-bodied animals (such as worms) always die, even when released alive; whence it has been inferred, with some plausibility, that the spines are the means of conveying into the prey some poisonous secretion, in the same manner as the poison-fang of the Serpent, or the sting of the Bee. Upon minute Crustacea and other hard-shelled animals, however, this secretion appears to have no power. Such animals are often swallowed alive, and their movements within the stomach may often be perceived for some little time; but, their life being at last destroyed, the process of digestion goes on very rapidly. The transparency of the membrane which composes the stomach, at first permits the outline of the animal to be clearly seen. The film over it gradually becomes turbid, however, and the outline of the animal indistinct; until, at last, its form is wholly lost. The soft parts are completely dissolved; and the harder indigestible portions are rejected through the mouth. This is, at least, the case with regard to the larger masses; the more finely-divided parts seem to be expelled through a small orifice at the opposite extremity of the cavity, evidently corresponding with that which, in the compound Hydraform Polype, opens into the tube that connects all the individuals by a common circulation (§ 1056). It would seem that Animal matter is more readily dissolved than particles of Vegetable structure.

1046. It not unfrequently happens that, in the process of swallowing, the Hydra draws in its own arms, which are coiled round its prey. The digestive process never seems to affect them, however, in the slightest degree; even though they remain thus inclosed during the whole period of the solution of the food. Trembley, the first discoverer of these Hydræ, to whose accurate description of their habits scarcely anything has been added by subsequent observations, once witnessed a very curious

circumstance. "Two Polypes had seized upon the same animal; both had partially succeeded in swallowing it; when the largest put an end to the dispute, by swallowing its opponent, as well as the subject of contention. Trembley naturally regarded so tragical a termination of the affray as the end of the swallowed Polyp's existence; but he was mistaken; for, after the devourer and his captive had digested the prey between them, the latter was regurgitated safe and sound, and apparently no worse for the imprisonment." It has been noticed that, when the Hydra is gorged with food, its tentacula may be touched with impunity by the animals, whose contact would at other times arouse it into active movement. This scarcely proves, however, an exercise of the *will*, to which some have referred it. We may easily understand that the distention of the whole of the tissues with fluid may be unfavourable to their contractility; and we have a parallel case in the Human being, for every one can perceive the difference in the facility of swallowing, at the commencement and termination of a full meal. It will scarcely be asserted that *this* variation is an effect of the will; in fact, it is often opposed to it, being one of those beautiful adaptations, by which the welfare of the economy is provided for, but which the indulgence of the sensual appetites opposes.

1047. When the difference between the external integument and the lining of the stomach is considered, it seems not a little wonderful that the two should be mutually convertible. Yet such is the fact. Amongst the many curious experiments performed on these animals by Trembley, was the following:—By means of a fine wire, he actually succeeded in turning the Hydra inside-out, as we might the finger of a glove; and this violent disturbance did not seem to interfere with the comfort of the animal, for all its functions soon went on as before. What was previously the lining membrane of the stomach now becomes the external integument, and from it the *buds* are produced, which will be presently described; whilst the tegumentary membrane seems to be capable of speedily doing all that is necessary, towards the digestion of the food. The remarkable power with which these Polypes are endowed of adapting themselves to circum-

stances, seems to be given to them as a compensation for their low degree of organisation. While the want of *cilia* on their tentacula prevents the creation of currents for the purpose of bringing a constant supply of food to the mouth, and thus affords less choice to the animal, the body is so constructed as to be capable of accommodating itself to a prey of extremely variable size; and the digestive secretion can act upon almost any kind of organised substance, so as to convert it into alimentary materials. And, in like manner, the absence of any special means of aerating the fluids is compensated by the exposure of every part of the tissue, both by its internal and external surface, to the surrounding element.

1048. The reproduction of the *Hydra* usually takes place by means of *buds* developed from its external surface. At first these appear as slight protuberances from the body; they gradually increase in size, and present somewhat of the form of the parent; an aperture is then seen at the unattached extremity, and tentacula sprout around it. During the whole of this period, the interior of the young Polype communicates with the general cavity of the parent. At first its nutriment is supplied entirely by the latter; but when the tentacula are developed, it catches prey for itself with much eagerness. It is not an unusual thing to see the young one and its parent struggling for the same worm, and gorging opposite ends of it together. There is still a communication between the stomachs of the two, as appears from the distention of either when the other is fed. As the young Polype advances towards maturity, however, this aperture contracts, and is at last obliterated. The stalk, by which the bud is attached, gradually becomes more slender; and at last it is broken by any slight effort on the part of either animal, and the young one swims off. Not unfrequently, however, it has begun to produce buds from itself, before its separation from its parent; and thus three generations may be seen united together. During warm weather, this multiplication goes on with great rapidity, if the animals are well supplied with food. From one parent, six or seven buds have been seen to sprout at one time; and, several of these bearing another generation, as many as eighteen

have been observed united in one group. Sometimes the whole process is concluded within twenty-four hours; so that, at this rate of production, above a million would be formed in a month from a single Hydra.

1049. It is not only in this manner, however, that the *Hydra* propagates itself. The process just described is evidently analogous to the extension by buds, which is so characteristic of Plants. But there is another mode of reproduction in the Vegetable kingdom—that by seeds or spores; and this, also, the Hydra possesses, in common with all the higher tribes of Animals. Towards autumn, some little gelatinous globules are seen to be liberated from the tissue of the Polype. These fall to the bottom of the water, and remain undeveloped until spring; when they produce a new generation of Hydræ, which are said to be smaller than those which have sprung immediately from the parent.

1050. Perhaps the most remarkable feature in the history of the *Hydra*, is its capability of reproducing the whole structure from separate portions of it. Not only will the body send forth new tentacula, to replace any which have been accidentally lost or artificially removed, but the arm thus separated has the power of developing the whole body. If the body is divided transversely, each segment will become a new animal; the upper one closing the aperture at its base, and the lower one speedily developing tentacula around the newly-formed mouth. If divided longitudinally, each half will form a separate tube in an hour, by the folding-in of its edges, and will soon begin to ply its tentacula. Even if divided into several longitudinal strips, each becomes a new tube; not as before, however, by the folding in of its edges, but by the formation of a cavity in its substance. If cut transversely into several segments, each will in time become a perfect animal, so that thirty or forty *Hydræ* may thus be produced by the section of one. Further, by slitting the tube at one end only, two heads or two tails may be formed—each division soon becoming perfect in itself. These may be again divided, and any amount of multiplication may thus be effected, thus realising in Nature the *Hydra* of ancient fable. The animal does not appear to suffer from these experiments, for it is

observed that, as if excited by the injury, young Polypes sprout more abundantly from the wounds thus made, than from unscarred parts. But even this is not all; for two Polypes may be grafted together by any parts; and not only two of the same species, but a green and a brown one may be thus united.

1051. The Polype does not seem to possess any special organs of sensation, or to have any kind of feeling but that of touch. It may be doubted, indeed, how far the greater part of its actions necessarily involve true *sensation ;* that is, how far it is conscious of the impressions which are made upon it, and to which its organs respond. Many of its movements present considerable analogy with those of Plants; especially those of the *Dionæa* (VEGET. PHYSIOL. § 422). The *Hydræ* generally seek the light; and, if a number of them be placed in a glass vessel, they will cluster at the side on which it strikes. We have no reason to suppose, however, that they are conscious of its presence *as light*, since no rudiments of visual organs can be detected. It would rather seem that it exercises an influence on their bodies, which causes them to seek it, very much in the same manner that Plants direct themselves towards it. The locomotive powers of the *Hydræ* are more exercised for this purpose than for the search after food. When seeking their prey, they generally fix themselves, by a kind of sucker at the lower end of the stomach, to some solid body; and their food is obtained by the tentacula alone. When they desire to change their place altogether, they do it in the manner of the geometrical Caterpillars (§ 702), and of some Leeches. If the foot or sucker be attached, the body is bent until the head touches the surface, along which it intends to move. It then adheres by the mouth, or by one or two of the tentacula; and, detaching the foot, draws it up into close proximity with the head. The foot then takes a fresh attachment; and the head is projected forwards, fixes itself, and is followed by the foot in the same manner as before. This mode of progression is, from the minute size of the animal, necessarily slow. A march of two inches occupies several hours for its performance; and seven or eight inches may be regarded as a very

good day's journey even in summer. But sometimes a more expeditious mode of travelling is adopted. The head being brought down and fixed as before, the foot is made to describe a semicircle over it, and takes its new attachment at an equal distance on the other side; the foot being then fixed, a similar movement is performed by the head; and thus the animal advances by a succession of somersets.

1052. By these and similar means, the *Hydræ* are enabled to move along solid surfaces, such as the bottom or sides of the vessel in which they are contained, and the leaves or stems of aquatic plants. There is another very curious position, to which it frequently has recourse. By projecting the flat surface of the foot above the water for a short time, it soon becomes dry, and in this state serves, by its repulsive action on the water around, as a kind of float, from which the animal suspends itself. In this state it can move itself, by means of its tentacula, with great facility; and it is also acted on by the wind, so that it can travel a considerable distance without effort. If, whilst thus floating, a drop of water be made to fall upon the foot so as to wet it, the hydrostatic power of the organ will be destroyed, and the animal will immediately sink to the bottom.

1053. The first subdivision of the Polypifera,—termed *Hydroida* or *Hydra-form*, or *Sertularian Polypes*, from the name of one of its most characteristic genera,—includes, with the simple genus just described, all those compound structures, in which a number of Polypes similar to it are associated together. In all these, the *polypidom*, or solid frame-work which gives support to the softer portions of the structure, is external to the living animal matter, and incloses it as in a tube. It is of a texture varying from that of membrane to that of horn; it never contains stony matter to any amount; and it is always flexible. This horny sheath is formed by the consolidation of the living animal membrane, which originally acts as the envelope of the soft and almost fluid texture within; and it is continuous with the external layer of that, which forms the Polypes themselves. This horny tube is enlarged at certain points into sheaths or cells for the protection of the Polypes;

within these the individuals can retract themselves, although, when in search of prey, they extend beyond it. Each single Polype resembles a *Hydra* in every important respect but this;—the stomach, instead of being nearly closed at the bottom, communicates freely with the interior of the stem and branches; and the membrane lining its sac may be regarded as a prolongation of that which surrounds their cavity. The pulp contained in the hollow stem, rather than the Polype itself, appears to be the essential part of the animal; for the latter is not only formed subsequently to it in the first instance, but frequently dies, and is reproduced by it.

1054. Of all Zoophytic productions, these structures are the most graceful in their appearance, and delicate in their conformation. They are very abundant on our own shores, seeming to prefer temperate to tropical climates; and they constitute a large proportion of what are commonly, but incorrectly, denominated *Corallines*.* They have generally a plant-like aspect; consisting of a stem, attached at its base (where it sometimes diverges into root-like prolongations) to some larger mass, and sending off its branches above with extreme and most beautiful regularity. The cells are arranged upon the sides of these, like the minute leaflets of Mosses; and it is not surprising,

FIG. 616.—SERTULARIAN POLYPES.

* The real Corallines are a much smaller group, probably of Vegetable character. In general aspect, their stems have some resemblance to those of the Sertu-

therefore, that by the older Naturalists, who were ignorant of the existence of the Polypes, these productions were regarded as of a vegetable nature, and were termed Sea-Mosses. The resemblance is still more striking when the mode of propagation in the two groups is contrasted.

1055. Although the reproductive gemmules are in some instances produced from the Polypes themselves, as in the Hydra, a more special apparatus is usually evolved for the purpose. At certain periods, there are formed from particular spots upon the stem of the *Sertularia* and its allies, expansions of its horny structure, somewhat resembling those which encase the Polypes, but usually larger. These *ovarial vesicles*, which so much resemble the *urns* of Mosses (VEGET. PHYSIOL. § 429), are like them provided with a lid, which falls off when the contained gemmules are mature, so as to permit their escape; and after their purpose is thus completed, the vesicles fall off, like the seed-capsules of all plants. The gemmules are usually clustered around a central column (analogous to the *columella* of Mosses); and when mature they swim forth by the action of the cilia with which they are provided, being detached from the central column at the same period that the lid of the vesicle falls off. The gemmules move to and fro by the vibration of their cilia, during a period which varies from a few hours to two or three days. When they have fallen upon a site fit for their development, they attach themselves to it by a root-like fibre, and then begin the formation of the polypidom. The real nature of this *gemmule* has been elsewhere explained (ANIM. PHYSIOL. § 745).

1056. All the *compound Hydroida* are inhabitants of the ocean. Some of them seem to attach themselves indiscriminately to any solid mass; whilst others seem to have a preference for some particular kind of support. Thus one is found only on rocks which are constantly beneath the surface; others on those which are occasionally uncovered by the sea; and others attach

larian Polypes; and hence they are associated together in the minds of those ignorant of this department of Natural History. The real Corallines may be distinguished by the absence of any trace of *cells* upon their surface.

themselves to the fronds of Sea-Weeds, which are exposed by the reflux of every tide. The deserted shells of Mollusca are the favourite bases of many species; and a few attach themselves even to these tenants of the deep whilst yet alive. The duration of these structures is various. Many of them do not exist above a year, especially such as are parasitic upon Algæ; but others, particularly those which attach themselves to rocks, probably attain a much greater age. It would seem, however, that the age of the Polypes cannot be measured by that of their cells. In some instances all the Polypes disappear during the winter, dying off like the leaves of a tree; and they are all renewed with the light and warmth of spring, whilst at the same time fresh branches are produced. In other species, a constant death and regeneration of the Polypes seem to take place.

1057. One of the most curious phenomena exhibited by the Polypes of this group, is the circulation which may be seen to take place in the stem and branches, and which seems to connect the different individuals together. This circulation much resembles that which has been described in the compound Ascidians (§ 979), and is, like it, *reversed* in its direction at intervals; but only a single current can be seen at a time; and it is not maintained by any visible movement of the walls of the cavities or tubes in which it takes place. The flow is sometimes very rapid; it then slackens, and at last stops; and recommences, sometimes immediately, sometimes after an interval, in the opposite direction. Five ebbs and flows have been observed to occupy about fifteen minutes.

Order II.—HELIANTHOIDA.

1058. No very evident links of transition exist between the different subdivisions of the class Polypifera; and we accordingly pass at once to the next group, of which the common *Actinia* (Sea-Anemone) may be regarded as the type. Although so different in size and general appearance from the Hydra, this is, like it, a *Polype;* and the difference will be found, on close

examination, to consist more in the relative development of the different parts, than in any fundamental change in their arrangement. The animal still consists principally of *a stomach;* this is provided with but one orifice, the *mouth,* which is fringed with numerous tentacula. Instead, however, of the delicate membrane composing the walls of the stomach in the Hydra, we have a dense fleshy sac, possessed of considerable firmness, but still very extensible. And, instead of the few long filamentous tentacula, we have a large number of short fleshy arms, arranged in several circles round the mouth. Further, instead of the prolonged pedicle or foot, with the minute sucker at its extremity, which has been described in the Hydra, we observe in the *Actinia* an expanded fleshy disk, which forms the whole base of the animal, and which is of size sufficient to take a very firm attachment to the rocks upon which it is fixed. The whole body may be likened to that of the Hydra in its most contracted state. When the *Actinia* closes its mouth, folds in its tentacula, and draws together the upper part of its body, it presents an almost hemispherical form—the flat side being attached to the rock, and the mouth being just visible at its summit; but when the animal expands itself, the body represents a short cylinder, the mouth becomes as wide as the base, and the fringes of tentacula display their brilliant colours to the light of day. The arrangement and appearance of these so much correspond with that of the petals of double flowers, still more with that of the flowerets of the Composite tribe, that it is by no means surprising that the uninformed observer should almost always regard this being as a member of the Vegetable Kingdom. The movements it exhibits are not, when superficially considered, very different from those which take place in certain Plants; and there is nothing ridiculous, therefore, in the appellation given to it by Hughes, who, in his Natural History of Barbadoes (a work published before the distinctions between the Animal and Vegetable Kingdoms were properly understood), denominates it *a sensitive plant having animal properties.*

1059. The *Actiniæ* are found on the shores of every sea. As in other tribes, each species has its peculiar haunt. In general,

we find them attached to rocks, which are alternately left dry and submerged by the tide. Sometimes, however, the portions which are constantly under water, are selected as their habitation; and they may be observed suspending themselves from the vaults of submarine reefs, or covering the sides of rocks as with a tapestry of flowers. Brilliant as are the colours exhibited by the species common on our own shores, when these are illumined by the direct rays of the sun, they are far surpassed by the glowing hues of the tropical Actiniæ; and the relative abundance of the two is nearly the same. Many voyagers have spoken with enthusiasm of the gorgeous spectacle presented by groups of these animals; and Le Sueur describes himself as with difficulty withdrawing from the contemplation of it, to collect specimens for examination.

1060. Here it may be thought, that the pursuits of the scientific investigator of Nature are inconsistent with that simple admiration of her beauties, which is capable of affording so high and pure a gratification to the most uninstructed mind. But it may be questioned whether the two are really incompatible, or whether, if rightly directed and cultivated, they do not strengthen each other. Need an acquaintance with the wondrous structure and curious habits of beings like those we are considering, diminish our pleasure in the contemplation of the beauty of their forms and the arrangement of their colours? And does it not become a source of still higher gratification, a pleasure more purely intellectual because less dependent upon the senses, when we regard these graceful forms and glowing hues, not only as beautiful in themselves, but as forming a part of that great scheme, in which Infinite Benevolence is so wondrously displayed in conjunction with Infinite Wisdom and Infinite Power. There are some who arrogate to themselves the title of "lovers of Nature," and affect to despise the minute acquaintance with detail, which the Man of Science aims at obtaining. They deem such knowledge injurious to that taste for her beauties, which, in their minds, is paramount to every other consideration. And there are others who run to the opposite extreme, overlooking, in their eagerness for scientific research into her more concealed

wonders, those beauties which are bountifully scattered over her surface, as if to invite us to further acquaintance. As an expressive countenance displays the workings of the mind within, combined with the beauty which itself possesses, and attracts us to the study of the mind which animates it, so should the varied beauties which abound on the face of Nature, lead us to the contemplation of that Mind which at first formed and which is continually acting through all. It is only when either of the tendencies above alluded to is indulged in its exclusiveness, that it can interfere with the other. Much will depend upon early education and habits; much upon subsequent self-training. For ourselves, we admire the feeling of Le Sueur, who walked for some time on the shore of the calm ocean, indulging his admiration of the beauties which it exhibited, before he could prevail upon himself to make even a slight interruption in the brilliant spectacle, of which he was the sole witness.

1061. The *Actiniæ* which attach themselves to rocks, sometimes adhere so firmly, that they cannot be removed without the laceration of their base. This fleshy disk adapts itself perfectly to the inequalities of the surface; and even sends down little prolongations into any pits or fissures that may exist in it. There is an interesting species inhabiting the British seas, the *Actinia maculata*, which attaches itself to dead shells, forming from its base a kind of horny expansion, that partly extends over their aperture. It has been remarked by Dr. Coldstream that in *all* the specimens which came under his notice, a Hermit-Crab had taken up its abode in the shell. It would seem, therefore, as if the addition made by the Actinia rendered the shell peculiarly suitable for the habitation of this tenant. Some species of Actiniæ confine themselves to the smooth sands, on the surface of which they spread out their tentacula, and beneath which they withdraw when danger threatens. Although the body has, in general, no further covering than the leathery envelope already mentioned, there are a few species (such as the *Actinia verrucosa* of the British seas) which, by means of a glutinous exudation from the body, form a kind of case by attaching together bits of shell, grains of sand, and other small substances. This casing

would seem to have for its purpose the concealment of the animal, as much as its direct protection. Individuals of the same species, inhabiting deep water, as if aware that they do not require such a mode of concealment, form no extraneous covering, but leave the surface clean; and this then acquires more vivid and varied tints, whilst the glandular warts by which the glutinous secretion is formed, become smaller, or disappear.

1062. The essential difference between the *Hydra* and the *Actinia* consists in this;—that in the former the stomach occupies the whole volume of the body, the membrane which lines it being the same with that which serves as the general envelope; whilst, in the latter, the stomach has walls of its own, being suspended (as it were) in the middle of the body, and leaving a considerable space between its exterior surface and the general envelope. This cavity is divided by vertical partitions, which

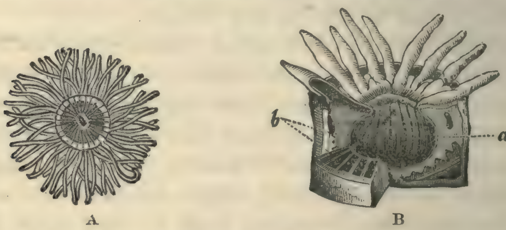


FIG. 617.—A, SEA-ANEMONE seen from above. B, SECTION OF SEA-ANEMONE; *a* cavity of stomach, *b* surrounding chambers.

pass in a radiating direction from one membrane to the other, so as to form a considerable number of chambers arranged round the central digestive sac. In these chambers the germs of young Actiniæ are evolved. There is not any regular communication between the chambers and the stomach; although it would seem that an opening must be occasionally formed, as young polypes are often sent forth by the mouth (§ 1067). The partitions all have openings, however, by which the chambers communicate with each other; and there is also a free entrance from them into the tubes of the hollow tentacula, which are formed of a membrane like the envelope of the body, and are provided with an orifice at their extremity, which the animal has the power of closing.

1063. The muscular structure of the fleshy base of the inner part of the general envelope of the radiating partitions, and of the circle round the mouth, is very distinct in the larger species of *Actinia*, and confers upon the animal considerable power in the prehension of food. Dr. Grant mentions that he has caused the common *Actinia crassicornis* to lift a basin of sea-water, weighing more than six pounds, by making it swallow the perforated shell of a Purpura, through the aperture of which a cord had been passed. By this cord the basin was lifted, without the Actinia quitting its hold—either of the shell in its contracted stomach, or of the basin to which its foot was attached. It is not surprising, therefore, that these polypes should be able to master not only shell-fish and other animals that have little means of active resistance, but even crabs, prawns, and other Crustacea of considerable size. These, indeed, seem to constitute its ordinary food. The luckless individual which walks over one of these stomachs gaping for its prey, is immediately secured by its tentacula, and in spite of its struggles is drawn into the mouth, which seems capable of distention to an almost unlimited degree. Sometimes the tail of a shrimp, or some other hard projecting appendage, will occasion a little trouble, and may be seen in active movement outside the mouth, when the mass of the body has been swallowed; but this is soon restrained by the tentacula, which entwine themselves round it, and gradually convey it into the stomach. These tentacula possess a remarkably tenacious power, which has been attributed to a glutinous exudation from them; but nothing of this kind can be seen on surfaces to which they have firmly attached themselves, and their adhesion is more probably due to the temporary conversion of a part of the arm into a sort of sucker.

1064. The digestive powers appear very considerable; for when Mollusca or Crustacea have been swallowed, the shells are subsequently rejected by the mouth, with not only their soft contents, but even their tendinous and ligamentous portions, dissolved away. It has been said that the Actinia sometimes swallows a shell, of which it cannot get rid in the usual manner, owing to its broad diameter being turned to the mouth; and

that the troublesome substance works its way out through the sides of the body, the artificial aperture soon closing, and the animal appearing to suffer but little inconvenience. In rejecting through its mouth the indigestible substances remaining within, the Actinia seems to draw up the stomach towards the orifice, so as the more completely to expel its contents. Sometimes this muscular action, which is assisted by the compression exercised by the general envelope, is carried so far, that the stomach is everted—completely turned inside-out—through the mouth. This fact is familiar to all, who have watched the habits of these animals on the sea-shore.

1065. The Sea-Anemone never seems to decline any article of food presented to it, on account of its bulk, but makes the most laudable attempts to swallow it, though occasionally compelled to relinquish its vain endeavours, and even to disgorge what it had partially swallowed. Sometimes the process of digestion is going on in the lower part of a mass which has been included in the stomach, whilst the remainder is projecting above the mouth, being gradually drawn inwards. It will hence be seen, that few animals surpass the *Actinia* in voracity. Nevertheless it is capable of fasting for a considerable period; or, at any rate, of subsisting upon no other nutriment, than the small quantity of animal matter that may be diffused through the sea-water, in which it is kept. It is after such a fast, that the efforts to swallow are most vigorous; and sometimes an amusing spectacle is presented by the contest of two for the same prey.

1066. Sea-Anemonies do not seem to exercise any choice in regard to food; but will swallow whatever is placed within the grasp of their mouth,—not even their own kind being exempt. They contract their tentacula and close the mouth, not only when mechanically irritated, but even when any change takes place in the amount of light to which they are exposed. When fully expanded, and displaying their glowing colours to the mid-day sun, a passing cloud will cause them to fold in their flower-like summits; and even the shadow of the hand will produce the same effect. The following interesting account of those inhabiting a rock-basin on the shore of Barbadoes, is given by

Hughes in his Natural History of the Island. "In the middle of the basin, there is a fixed stone, or rock, which is always under water. Round its side, at different depths, seldom exceeding 18 inches, are seen at all times of the year, issuing out of little holes, certain substances that have the appearance of fine radiated flowers, of a pale yellow, or a bright straw colour, slightly tinged with green, having a circular border of thick-set petals, about the size of, and much resembling, those of a single garden marigold. I have attempted to pluck one of these from the rock, to which they are always fixed, but never could effect it: as soon as my fingers came within two or three inches of it, it would immediately contract close together its yellow border, and shrink back into the hole of the rock; but if left undisturbed for about four minutes, it would come gradually in sight, expanding, though at first very cautiously, its seeming leaves, till at last it appeared in its former bloom. However, it would again recoil, with a surprising quickness, when I came within a little distance of it. Having tried the same experiment by attempting to touch it with my cane and a slender rod, the effect was the same." This last statement shows a high degree of sensibility to light; since there is no reason to believe that any special organs of vision are possessed by these animals, which can enable them to *see* objects in their neighbourhood. They appear also to be, like some plants, very easily influenced by atmospheric changes; and this, even when kept for some time within-doors. The Abbé Dicquemare, who watched their indications for many years, considered them a most valuable marine barometer; fine weather being indicated by their expansion, bad weather by their closure, and very boisterous weather by their extreme contraction.

1067. These movements are not the only ones, however, unconnected with the prehension of food, exhibited by this interesting animal. It is observed frequently to distend itself with water, so as to attain many times its usual size,—the membranes of its body becoming proportionally thinner. This water is not taken in by the mouth alone; indeed it is doubtful if any enters there under these circumstances; at any rate, the chief part is introduced through the orifices at the

extremity of the tentacula, and the distension exists in the radiating chambers and arms rather than in the stomach. The water is afterwards expelled in jets through the same orifices with considerable force; so as to rise to the height of a foot or more. There is reason to believe that this process is chiefly one of respiration. The whole interior of the chambers, into which the water is received, is covered with vibratile cilia; and it has been observed that, if Actiniæ are kept in a limited quantity of water, from which the air is soon exhausted, the distension of the body is enormously increased, so that its appearance almost resembles that of an inflated bladder. Sometimes this distending process appears to be performed for the purpose of facilitating locomotion. The animal is then almost of the same specific gravity with water; and, if it withdraws its foot from its attachment, it is carried away by the least agitation of the water, and may thus go in search of a new abode without exertion of its own. When it is cast upon a surface adapted to its wants, it forms a new attachment; and there remains, until deficiency of food or some other cause again excites it to removal. It would appear that, when thus supported by the water, it can use its tentacula for assisting in its movements; and can even *walk* upon these, turning its mouth downwards. It can, however, glide along the surface of a rock, by the alternate contraction and expansion of the fleshy foot in one particular direction, —in just the same manner that the Snail, or other Gasteropod Mollusca, perform their movements.

1068. The power enjoyed by the *Actinia* of reproducing parts of which it has been deprived, is almost equal to that possessed by the Hydra (§ 1050). Our knowledge of it is principally due to the experiments of Dicquemare. He found, that if the tentacula be cut off, they are soon replaced. If the body be divided transversely,—so that the upper portion possesses a mouth and tentacula but no base, and the lower one has the base and open stomach without a regular mouth or tentacula,—both parts will continue to live, the one gradually closing its under side,* and forming a new disk, the other after some

* This is not always the case, however. In one instance, a new set of tentacula were sent forth, and a complete new mouth formed, at the lower orifice; so that the animal could take food by either.

months acquiring a complete new set of tentacula and a perfectly-formed mouth. The upper part did not seem conscious of the loss of its base; but, like Baron Munchausen's celebrated horse, took food presented to it, even though it passed out almost immediately by the orifice newly-created below. If the body be divided vertically, each half becomes in time a perfect animal, capable of performing all its functions; and it would appear that such a division occasionally takes place spontaneously. The following very curious instance of the power, which the structure of this animal has, of adapting itself to circumstances, is related by Dr. Johnston. "I had once brought me a specimen of *Actinia gemmacea*, that might have been originally two inches in diameter, and that had somehow contrived to swallow a valve of *Pecten maximus* of the size of an ordinary saucer. The shell, fixed within the stomach, was so placed as to divide it completely into two halves, so that the body, stretched tensely over it, had become thin and flattened like a pancake. All communication between the inferior portion of the stomach and the mouth was of course prevented; yet, instead of emaciating and dying of an atrophy, the animal had availed itself of what undoubtedly had been a very untoward accident, to increase its enjoyments and its chances of double fare. A new mouth, furnished with two rows of numerous tentacula, was opened upon what had been the base, and led to the under stomach: the individual had indeed become a sort of Siamese twin, but with greater intimacy and extent in the union."—It sometimes happens that, in tearing away an *Actinia* from the rock, some portions of the disk are left behind; and even these are said to be capable of developing perfect individuals. The following circumstance is mentioned by Hughes, in the account already quoted. "Many people coming to see these strange creatures, and occasioning some inconvenience to a person through whose grounds they were obliged to pass, he resolved to destroy the objects of their curiosity; and, that he might do so effectually, caused all the holes out of which they appeared to be carefully bored and drilled with an iron instrument, so that we cannot suppose but their bodies must have been entirely crushed

to a pulp; nevertheless they appeared in a few weeks from the very same places." The *Actiniæ* have not only the power of repairing injuries of this description, but seem to resist the effects of other agents in a very remarkable manner. They are not killed by being frozen in a mass of ice, but return to activity when thawed; and they withstand the action of water heated to 140°. They may be placed with impunity in the exhausted receiver of an air-pump; and yet their life is destroyed in a few minutes by immersion in fresh water.

1069. We do not find in the *Actiniæ* anything exactly resembling the reproduction by *buds*, which is so remarkable in the Hydra. The spontaneous division of the body just alluded to,—which is said to take place occasionally, not into two parts only, but into several—constitutes an approach to it. The special reproductive apparatus, by which distinct germs are formed, is here very highly developed; consisting, as already described, of a series of chambers, surrounding the stomach, within which they are developed. They sometimes pass out by the tentacular orifices, in the state of simple gemmules furnished with cilia, like those of other polypes. Sometimes, however, they are retained for a longer period, and their development goes on within the body of the parent, so that when liberated they already present something of the form of the adult animal, having a mouth, stomach, and tentacula,—the latter being at first few, but gradually increasing in number. In this state they generally find their way out by the mouth of the parent; and Dicquemare says that he has had eight or ten born in his hand at once. In the course of six years, an *Actinia*, kept by Sir J. Dalyell, produced above 276 young. If all these had been preserved, and their progeny reckoned, the amount would have been enormous. The young are frequently disgorged along with the half-digested food; thirty-eight appearing thus, in various states of development, at a single litter. Monstrosities are not uncommon among the young. One is mentioned by Sir J. D., which had two perfect bodies springing from a single base. When one body was gorged with food, the other continued ravenous.—The process of respiration already described,

appears to have an important connexion with the development of the progeny; and the introduction of water into the ovarial chambers may not improbably furnish them with supplies of food as well as of air.

1070. The *Actiniæ* have been stated to feed upon small Crustacea, Fish, &c. In their turn, they become the prey of the larger species of these tribes. They constitute by no means an unpalatable article of food, even for Man. Particular species are highly prized as delicacies in some tropical countries; and others are commonly employed by the inhabitants of northern shores. Along our own coasts, there is a remarkable neglect of these and of many other marine productions, to which, if not constantly employed, recourse might be advantageously had in times of scarcity. They seem to have been a favourite dish at the Abbé Dicquemare's table. "Being boiled some time in sea-water," he tells us, "they acquire a firm and palatable consistence, and may then be eaten with any kind of sauce. They are of an inviting appearance, of a light shivering texture, and of a soft white and reddish hue. Their smell is not unlike that of a warm crab or lobster." A few species have the power of stinging, like the Acalephæ with which they were associated by former naturalists.

1071. The *Actiniæ* are by no means the only Polypes belonging to this Order. Several other genera exist, of which some are, like it, unpossessed of any calcareous deposit, whilst others form a hard skeleton more or less complete. Between these, however, there are links of close connection; for some among the first have a portion of the base and of the lower part of the cylindrical body hardened into a kind of horny cell, within which the animal can retract the upper portion that remains soft. In those species which construct a stony basis, the calcareous matter is deposited in the same situation. Such a deposit is formed by the *Caryophyllia*, a solitary Polype much resembling the Sea-Anemone, which is to be met with on the southern shores of England; and thus a stony cell is formed, in the bottom of which are to be seen a number of thin vertical plates or *lamellæ*, formed in the partitions between the ovarial

chambers, and, like them, *radiating* from the centre towards the circumference of the cell. These radiating lamellæ are, in fact, characteristic of all the Coral structures formed by the group of Helianthoid Polypes; being present, more or less evidently, in every one known to be the work of these animals, and not occurring in any, of which the animal is known to resemble either of the other groups. The cells are not by any means constantly circular; but still the laminated plates project inwards from their circumference, so as to occupy a corresponding position. The Madrepores and their allies have thence been designated *lamelliform* corals; a term which is very expressive of their character, and has the advantage of relating to the structure of the animals which produce them.

1072. Some species of *Caryophyllia* build up their cells in a cylindrical form, to a considerable height (Fig. 618). As the upper edge is extended by the gradual consolidation of the soft structure, which is the continuation of it, the lower part is strengthened by new deposits, which are added to the bottom of the cell; so that a stony column is thus formed, which may almost be described as solid through nearly its whole extent. It is not uncommon to meet with several of these, clustered in one mass; and thus we can understand the production of those arborescent (tree-like) forms, to which the name *Dendrophyllia* has been given. In these, the stem sends out branches, instead of remaining simply columnar; and these branches again subdivide; in all instances, however, the cells *terminate* the branches, which increase in length by the progressive consolidation of their basis, just as in the solitary species. The whole structure is covered with a gelatinous flesh of some consistence, which seems to be continuous with the outer membrane of the Polypes inhabiting the cells. This flesh appears to have the same functions with the pith of the Sertularian Polypes. It seems, in fact, to constitute *the*

Fig. 618.—Caryophyllia.

animal, of which the Polypes are only subordinate parts. It has no direct communication with their stomachs, however ; nor does it appear to connect the different Polypes very intimately together. But it is largely concerned in the deposition of the calcareous matter of the polypidom, especially in those forms of it in which the cells are connected together by a solid mass (Fig. 619), instead of being seated, as in the *Dendrophyllia*, upon the extremities of diverging branches. Even here it may be observed, however, that a new twig or ramification is at first produced, not by a Polype, but by a projection of the flesh, of which the centre becomes consolidated, forming a cell in which the Polype subsequently appears. The same takes place in the early development of the gemmules. Moreover, if a piece of this flesh be stripped from the surface and placed in sea-water, it will begin to form a cell, by the deposition of calcareous matter, upon the spot where it happens to rest ; and this cell is soon tenanted by a Polype like an *Actinia*. Many other arborescent forms of lamelliform corals might be enumerated, which are of great beauty to the common observer, and highly interesting to the Naturalist on account of their affinity with the extinct species so abundant in limestone rocks.* Amongst these are the true *Madrepores*, in which the whole surface of the stem and branches is covered with minute cells. In all these, as in the plant-like *Sertularidæ*, the living flesh is withdrawn from the lower part, in proportion to the extent of growth above ; and, if attached to a limestone rock, the root can scarcely be distinguished from the basis on which it has been implanted.

1073. We now pass to another series of forms presented by the lithophyte corals ;—those in which the Polype-cells, instead of being placed on the ends or sides of branches, are distributed over a continued surface, sometimes in close apposition with each other, sometimes widely separated, but united by a solid calcareous mass which fills up the interspaces. Of the first of these kinds, the common *Astræa* affords an excellent example. We might

* It may be desirable to remark that the *Red Coral* and its allies do *not* belong to this group, being destitute of laminated cells. They will be described among the Alcyonian Polypes (§ 1093).

imagine it composed of a number of *Fungiæ* packed closely together. Here the same gradual consolidation of the lower part of the cells takes place, as in the *Caryophyllia;* so that the mass acquires considerable thickness. The cells of these Polypes do not always, however, preserve their regular rounded form ; being sometimes oval, and in many instances forming a long furrow, as in the *Meandrina.* Each of the furrows, however, is occupied by several Polypes arranged side by side; and their point of junction is usually indicated, either by a slight transverse partition in the furrow, or by a change in the direction of the laminæ arising from its sides. In the *Meandrina cerebriformis* (brain-stone coral), the whole mass, whether young or old, is nearly hemispherical. It is at first small, but extends in all directions by a process of growth and consolidation analogous to that already described; so that, whilst its surface is always covered with a living flesh, and studded with vast numbers of polypes, the interior is a mass of solid limestone, the particles of which remain cemented together by the animal matter in which they were at first deposited. On breaking this hemispherical mass, the ridges which bound the furrows may be traced inwards through its substance, even to the central nucleus from which they commenced ; the deposit in the interstices of these being of a softer character, and possibly more of the nature of an exudation from the under surface of the flesh. These *Meandrinæ* sometimes attain a considerable size. Ehrenberg noticed single masses, in the Red Sea, from six to nine feet in diameter. Their rate of growth, however, appears to be slow.

FIG. 619.—MASS OF ASTRÆA VIRIDIS ; *a, a,* expanded Polypes : *b, b,* Polypes withdrawn into their cells ; *c,* stony mass uncovered by flesh.

1074. It is principally by the animals of this group, that

the formation of coral reefs and islands is effected. Many errors have prevailed upon this subject, both as to the rapidity of their extension, and the depth from which they are built up to the surface of the ocean. It has been commonly stated that many channels and harbours in the Red Sea have been closed up, within the memory of man, by the rapid increase of coral limestone. But Ehrenberg, who carefully examined these localities, attributes the obstruction rather, in some instances, to the quantities of coral sand which have been washed into the harbours, and in others to the accumulation of ballast (generally composed of pieces of coral rock) thrown out from vessels. In Captain Beechey's late Expedition to the Pacific, no positive information could be obtained of any channel having been filled up within a given period; and he states, as an indisputable fact, that several reefs had remained, for more than half a century, at about the same depth from the surface. On the other hand, there is evidence of the occasionally rapid growth of these structures. In the Museum of the Bristol Institution is a mass of *Agaricia*, weighing 2 lbs. 9 oz., surrounding a species of Oyster, whose age cannot be more than two years. Pieces of coral, detached from a reef, and thrown into some other situation, soon become fixed by the deposition of new stony matter, if the animal flesh have not been too much destroyed; and in this manner a sort of artificial reef may be formed in any spot desired, provided the depth of water be suitable. The natives of the Polynesian Islands have long employed this method for building their piers, wharfs, fish-preserves, &c. Mr. Stutchbury mentions that he saw, at the Island of Taapoto, in about seven fathoms water, the anchor of a large ship, wrecked there not more than fifty years previously; this was completely incrusted by coral, though it preserved its original form. One of the most interesting proofs of the occasionally rapid growth of Coral, is afforded by the alteration in form which is seen in two kinds of shells that inhabit the reefs—the *Vermetus* and *Magilus* (§ 926).

1075. There can be no doubt that, whether the growth of Coral takes place as rapidly as some maintain, or as slowly as it is believed to do by others, it is among the most important of

the progressive changes, which have been altering the surface of the Globe since it has been tenanted by Man. To it is due the existence of a large proportion of the Islands of the Polynesian Archipelago, as well as many of those in the Indian Ocean; and the extent of these islands is far less than that of the reefs, which are not yet raised above the level of the sea,—some presenting themselves at a distance from any upraised land, others fringing the shores of continents and islands, composed of other formations. It is not correct, however, to affirm (as has been frequently done) that these islands and reefs have been upreared by the Coral-polypes from the depths of the ocean. It is now satisfactorily ascertained that no known species can build from a greater depth than twenty fathoms; and a large proportion seem to prefer a depth of from twenty to thirty feet. As very deep water is found in the immediate neighbourhood of many of these reefs, the question arises, upon what basis they are constructed; and to solve this, it is necessary to look at the forms which these massive structures present.

1076. A large proportion of the Coral Islands of the Polynesian Archipelago are shaped like a crescent, sometimes like a complete ring; and these islands never rise many feet above the surface of the ocean. The highest part is always on the windward side,* against which the waves are almost constantly dashing. Within the crescent or ring is a basin, termed a *lagoon;* and this usually communicates with the open sea, by a channel, sometimes of considerable width, on the leeward side of the island. Occasionally this channel is completely filled up by the growth of the Coral; and the lake, thus inclosed, only communicates with the sea by filtration through the Coral rock. The Coral-polypes never build above low-water mark; and they are not, therefore, immediately concerned in the elevation of the surface from beneath the waves. This is principally accomplished by the action of the sea itself. Large masses are often detached, by the violence of the waves, from the lower part of the structure; and

* The prevalence of *easterly* winds in the tropical regions, causes this name to be given to the eastern side of islands situated there; the western shore being known as the leeward.

these (sometimes measuring six feet by four) are washed up on the windward side of the reef. Shells, coral-sand, and various other *débris*, accumulate upon it in like manner, until it is at last changed into an island, upon which there is a calcareous soil capable of supporting various kinds of vegetation. When these have once established themselves, the elevation of the surface continues with greater rapidity—successive layers of vegetable mould being deposited by the rapid and luxuriant vegetation of these tropical islands, which are soon tenanted by various forms of animals, and at some subsequent period afford a habitation to Man. It is not usually, however, until after the windward coast has attained considerable elevation, that the leeward side is perfectly closed in. Two causes may be assigned for this. There seems to be a natural instinct on the part of the animals, which impels them to build with greater rapidity on the most exposed side; and the leeward side is therefore the part last completed. Moreover the closure of this passage is impeded by the current almost constantly passing out of it, which is caused by the dashing of the waves over the windward side into the lagoon; and until this ceases, there will always be a free exit in the opposite direction. After the wall has been sufficiently upraised, however, the lagoon is often completely enclosed. In the centre of this lagoon, deep water is often found, and no living animals can be seen upon its bottom; but the shelving edges of the shallower portion are clothed with luxuriant growths of the more delicate species of coral, and its waters abound in marine animals of all descriptions.

1077. These lagoon-islands vary in diameter from one to fifty miles; the breadth of the elevated ring which encloses the lagoon, is from 400 or 500 yards to about a mile, though seldom above half a mile; and its height above the water is not often more than four or five feet in any part. The annular (ring-like) character of these islands naturally suggests the idea, that they may have been built upon the edges of submarine volcanoes, or upon circular elevated ridges, forming basins, resembling those which abound in the parts of the globe at present upraised, and which may reasonably be supposed to exist in those still submerged.

In support of this doctrine, it has been stated that fragments of volcanic rocks have been found in the water of a lagoon. That there is nothing in the essential nature of coral structures which impels them to assume this form, is evident from the fact mentioned by Ehrenberg, that in the Red Sea the islands are oblong or square without lagoons; as well as from the variety which we meet with even in the Polynesian Archipelago. In fact, they always appear to correspond with the form of the base on which they are erected; and the evidence that some lagoon islands (at least) are founded upon the tops of submarine volcanoes, or upon the edges of large basins, seems therefore satisfactory. But it is difficult to conceive that there should exist beneath the ocean so large a number of summits, all so nearly approaching its surface, as these must do in order to form a basis for coral *islands*,—not to mention the other ridges on which the *reefs* are built, which will next be noticed. This difficulty appears to be solved by the very ingenious hypothesis lately put forth by Mr. Darwin, which will be presently explained.

1078. Almost all the shelving shores of tropical seas are fringed more or less closely by ridges of Coral. These are not built immediately upon the edge of the land, but at some little distance from it. If the wall of coral were upraised close in-shore, the fresh water draining down from the land, and entering the basin thus formed, would render it unfit for the habitation of the Polypes. They are, therefore, endowed with a power of choosing a situation more advantageous to their growth; and we accordingly find these *skirting reefs* upraising themselves at some distance from the shore, but not so far off as to have a base of greater depth, than is suitable to the constitution of the Polypes. Very often such reefs run from point to point of a bay, so as completely to enclose it.* But beyond these skirting reefs are

* In the little island of Cariacou (one of the chain of Grenadines, between Grenada and St. Vincent) the whole coast is a succession of such bays, and each of these is shut in by such a reef; a narrow passage into one of them being the only means of access, when the Author visited it a few years since. From a hill in the centre of the island, nearly every part of the coast can be seen; and the white lines of surf, connecting the dark rocky points, present a very striking appearance. The Society Islands are generally skirted by similar reefs, which are generally 400

sometimes other ridges, often at a considerable distance from the shore, but still preserving a direction parallel to it. These are termed *barrier reefs;* and the most remarkable of them is the one, which stretches along the north-eastern coast of New Holland. The total length of this is above 1000 miles; along 350 miles there is no break or passage whatever; and for 700 miles northwards towards New Guinea, there are no intervals exceeding thirty miles in length. When we endeavour to account for such a structure upon the commonly received opinions alone, we are met by the same difficulty as that, which opposes itself to the supposition of a rocky base to all the coral islands, at a depth of less than 120 feet. There is no mountain range, extending to anything like the length of this reef, of which the summits are so nearly equal in height;—still less any one presenting a continuous ridge, such as would be required for the base of the uninterrupted portion of the reef. We have, therefore, no right to suppose that such a ridge should arise from the depths of the ocean; and yet without it, our knowledge of the habits of the Coral Polypes does not enable us to account for the remarkable structure under consideration.

1079. This difficulty, however, appears to be satisfactorily solved by Mr. Darwin's hypothesis. He has adduced several reasons for the belief, that the bottom of the whole Pacific Ocean is changing its level, in some parts slowly subsiding, whilst in others it is undergoing gradual elevation. Now if we imagine the whole of New Holland to have been at a former time considerably more elevated than at present, its area would of course have been greater, and it might have extended to the line of the present reef. This reef might have then been formed as a *skirting reef* in the usual manner; stretching at the distance of a few hundred yards along the whole coast in shallow water. If a *slow* subsidence then took place, the coral would be kept up to the surface of the water, by the labours of the Polypes, in an almost unbroken ridge; whilst the water would gradually gain

or 500 yards off-shore, with a deep channel, into which ships can enter by numerous passages.—These passages are generally opposite the mouths of fresh-water rivulets.

upon the land, and increase the distance of its shore from the reef. In this manner the *skirting reef*, upraised from a depth of ten or fifteen fathoms, and at a distance of five hundred yards from the shore, may be gradually converted into a *barrier reef*, with water one hundred and fifty feet deep on each side of it, and the shore one hundred miles off. Let us imagine the gradual subsidence to continue, until the whole of New Holland should be submerged, with the exception of its loftiest hills. These would then remain as rocky islands rising out of the ocean; but the barrier reef would continue in its present aspect, since it would be still maintained on a level with the surface, by the labours of its innumerable builders, although the depth of its base would be constantly increasing. If a *rapid* subsidence were to take place, however, the summit would be submerged to a depth inconsistent with the vitality of the Polypes; and all increase must then cease.

1080. It is evident that this hypothesis will be equally applicable to the case of the lagoon-islands. If the area over which they occur were formerly more elevated, some of its volcanic peaks and circular ridges might have lifted themselves high above the ocean; others would have been nearer its level; and others might have been just submerged. Upon the latter, the formation of coral would have begun; and circular reefs would have been built up to the surface. If a slow subsidence then took place, these reefs would still retain their surface-level by addition, whilst a new set of hills would be submerged, and would serve as bases for new coral islets. In this manner all the summits, however different their original elevation, would be rendered of an uniform height; each, as it was submerged, becoming the basis of a coral growth, which keeps pace with the progressive lowering of the whole mass;—and so on until all are thus submerged, and no land but coral islets remains above the surface.

1081. This very ingenious hypothesis corresponds well with the fact that, over certain large areas of the Pacific, we find lagoon islands and barrier reefs abundant, whilst skirting reefs are scarcely ever met with. Moreover, actual proof of a slow

subsidence is not wanting. Thus in the Keeling or Cocos Islands, situated in Lat. 11° 50′ S., and Long. 96° 51′ E., the old cocoa-nut trees surrounding the lagoon, in which the water is as tranquil as in the most sheltered lake, are undermined and falling. The foundation posts of a store-house, which, according to the inhabitants, had stood seven years before just above high-water mark, were, at the time of Mr. Darwin's visit, washed by the tide. The islands are occasionally shaken by earthquakes. Such changes are by no means unfrequent in many parts of the Pacific; and, if the accounts of the natives are to be relied on, many instances of the submergence of whole islands have occurred, within the period of recent tradition.

1082. The evidence in regard to the areas of elevation is still more satisfactory. It is by no means uncommon to find beds of recent Coral, at a considerable height above the sea level. Sometimes whole coral islets are thus upraised. Among these, Elizabeth or Henderson's Island, examined by Captain Beechey, is one of the most remarkable. This is about five miles in length and one in breadth. It has a nearly flat surface; and on all sides, except the north, is bounded by perpendicular cliffs about fifty feet high, composed entirely of dead coral. In some parts, the height of the surface was nearly eighty feet above the water level. The face of the cliffs presented a smooth surface, and was destitute of any ridges or other indication of the action of the sea at different levels; so that it may be reasonably inferred, that it was upraised by one convulsion. At a distance of a few hundred yards of this island, no bottom could be gained with 200 fathoms of line.—The most remarkable instance of this kind on record is the one observed by Mr. S. Stutchbury in the island of Tahiti. This island is composed of volcanic rocks; and there is in it a lofty mountain ridge with two summits, of which the lower one is evidently the crater of a volcano, perhaps not very long extinct. The principal peak rises to the height of about 10,000 feet; and near its summit is a distinct and regular stratum of coral-limestone, which cannot be distinguished from that, which is being at present formed in enormous quantity around the shores of the island. As there is no other deposit of

coral, either on the sides of this mountain, or on the summit of the volcanic crater, it is a reasonable inference that the island must have been upraised, to the whole amount of the elevation of the ancient ridge of coral above the reefs at present in course of formation, at *one movement*.—In the bands of the Pacific Ocean, regarded by Mr. Darwin as areas of elevation, no lagoon islands or barrier reefs are met with; but the shores are fringed by skirting reefs; and active volcanic changes are not of unfrequent occurrence.

1083. The following remarks by Mr. Darwin form a very appropriate conclusion to this part of our subject:—" It is not that the ocean spares the rock of coral; the great fragments scattered over the reef, and accumulated on the beach, whence the tall cocoa-nut springs, plainly bespeak the unrelenting power of its waves. Nor are there any periods of repose granted. The long swell, caused by the gentle but steady action of the trade-wind always blowing in one direction over a wide area, causes breakers, which even exceed in violence those of our temperate regions, and which never cease to rage. It is impossible to behold these waves, without feeling a conviction that an island, though built of the hardest rock, let it be porphyry, granite, or quartz, would ultimately yield and be demolished by such irresistible forces. Yet these low insignificant coral islets stand and are victorious; for here another power, as antagonist to the former, takes part in the contest. The organic forces separate the atoms of carbonate of lime one by one from the foaming breakers, and rear them up into a symmetrical structure. Let the hurricane tear up its thousand huge fragments; yet what will thus tell against the accumulated labour of myriads of architects at work day and night, month after month. Thus do we see the soft and gelatinous body of a polypus, through the agency of the vital laws, conquering the great mechanical power of the waves of an ocean, which neither the art of man nor the inanimate works of nature could successfully resist."*

1084. Much discussion has taken place in regard to the sources, from which the Coral-polypes obtain the enormous quan-

* Darwin's Journal, p. 548.

tity of lime deposited by them; and this question affects not only those of the present epoch, but those of former ages, to whose labours, in conjunction with those of the testaceous Mollusks, the greater part of the Calcareous strata of the secondary and subsequent periods are immediately or remotely due. Some have gone so far as to imagine, that the lime is *produced* by some organic process in the animals themselves. No positive evidence of such a production can, however, be obtained from any source; and the hypothesis is quite unnecessary in the present instance. We have reason to believe that lime existed in large quantities on the surface of the earth, before any organised beings were placed upon it; and there is also ground for supposing, that a larger quantity of carbonic acid existed in a free state at that epoch, than at the present time. It is not improbable, therefore, that the waters of the ocean contained a much larger quantity of lime than they now do—this ingredient being held in solution by the free carbonic acid; and the enormous beds of calcareous rock, separated by the action of Coral-polypes, are therefore easily accounted for. Moreover, in volcanic countries at the present time, springs charged with carbonate of lime thus held in solution are very abundant; and it is not unfair to suppose that,—as the part of the globe in which the coral-formations increase most rapidly (the Pacific Ocean), is also one of the chief areas of submarine volcanic action,—such springs may occur with similar frequency, and may greatly assist in the growth of these masses. In illustration of this doctrine, it is remarked by Mr. Lyell that, in lakes which have no unusual supply of carbonate of lime, there is no accumulation of shell-marl—the thin shells of one generation of Mollusks decomposing, so that their elements supply the requisite materials to succeeding races. But, if springs or streams charged with carbonate of lime enter such a lake, the shells accumulate and form marl. There are many plants and animals, in whose economy lime appears to be an important agent; and the quantity introduced bears a strict relation (within a certain limit) to that with which they are supplied.

Order III.—ASTEROIDA.

1085. Having thus considered the two Orders, in which the structure of the single and associated Polypes is most characteristically presented, we may pass on to the two others; which exhibit such modifications of this structure, as connect the Polypifera with the classes below and above them.

1086. We shall first consider (as being most nearly allied to the preceding) the Order, which, from one of its principal genera, we may term that of *Alcyonian* Polypes. In many of these, the polypidom, or solid framework, so closely resembles Sponge, that, in the dry state, the former can only be distinguished by the regular disposition of cells upon its surface; and, in the immature condition, the resemblance is still more close,—the young branches of the polypidom, on which the polypes have not yet appeared, presenting all the characters of sponge, as will be presently shown (§ 1088). There is a greater apparent diversity in the character of the members of this Order. Whilst one family approaches the Sponges so closely, that it may be almost regarded as formed of Sponges provided with polype-mouths, another has a dense horny, or even calcareous, arborescent stem; whilst in another, the soft parts of the body are entirely inclosed in a firm tubular sheath. But, however different in the character of their aggregated masses, they all bear a general resemblance, as to the structure of the individual polypes; and to these we shall first, therefore, direct our attention.

1087. None of the *Alcyonian* Polypes live so entirely isolated as the *Hydra* or *Actinia*. The closeness of the connection between the individuals, differs extremely in the various groups; for whilst, in the lower forms which assimilate with the Sponges, the Polypes seem quite subordinate to the general mass, from which they are developed, and to the support of which they minister in common,—there is another group, in which each seems to live for itself alone, although united externally with its fellows. In all, however, the essential characters of the Polypes

remain the same. On comparing the external appearance of one of them with that of a *Hydra* or *Sea-Anemone*, we perceive that, whilst the mouth is surrounded by tentacula as in them, there is a marked difference in the form and number of these prolongations. Instead of long delicate filaments like those of the *Hydraform* Polypes, or short cylindrical tubes like those of most of the *Actiniæ*, we find six or eight broad leaf-like expansions, disposed with great regularity around the mouth, so as very much to resemble a Star-fish (Asterias). Hence the term *Asteroida* has been proposed as a designation for the group; and it represents sufficiently well its chief external character. These tentacula are unprovided with cilia; but a number of little projections may be seen along their margins, which probably increase their prehensile power. The mouth leads into a stomach, which resembles that of the *Actinia*, in being suspended in the midst of the general cavity of the body, by partitions radiating from its walls. Instead of being closed at its lower extremity, however, it opens like that of the *Sertularians*, into the canals which ramify through the fleshy mass, and which thus connect all the Polypes into one system. This opening is surrounded by a circular muscle, or sphincter, by the action of which it may be expanded or entirely closed. The chambers which surround the stomach correspond in number with the tentacula; and these are hollow, opening below into the chambers (as in the Actinia), whilst they have a small orifice at their extremity. The chambers are continuous at their lower part with the ramifying canals just mentioned; and the membranous folds which support the stomach do not cease at its lower extremity, but are prolonged downwards as plaits of the lining of these canals, until they gradually disappear.

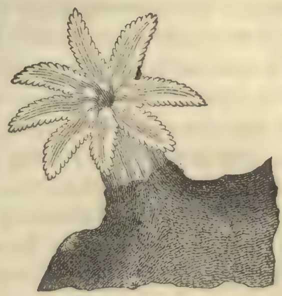


FIG. 620.—ALCYONIAN POLYPE.

1088. The ova or germs are developed in the substance of the membranous folds, or from the lining of the canal. They grow like seeds in a seed-vessel; at first appearing as little protuberances from the plane surface; then acquiring a distinct globular form, and remaining attached by a little stalk; and finally, being liberated by the separation of this pedicle. They then make their way outwards, by passing into the stomach through its lower aperture; and finally escape by the mouth. Like the gemmules of other Polypes, they consist in this state of a membranous bag including fluid; and they are covered with cilia, by the action of which they move freely through the water for some time before fixing themselves, though not with the same rapidity as the ova of some other Polypes. They are usually coloured with great vividness; and, during their motions, they often contract themselves and alter their form.

1089. Very little is known of the general habits of these Polypes; but they probably differ but little from those of the groups already described. We may pass on, therefore, to consider the chief subdivisions of this Order, which includes many very interesting and well-known forms. These subdivisions are principally founded upon the nature of the polypidom; and it is desirable, before proceeding to describe them, that the relation of the parts of which the animals are composed should be clearly understood. Delicate as is the membrane of the Polypes themselves, it may be distinguished, like that of the Sertularians (§ 1052) into two layers.—Of these, the outer one is continuous with the general envelope of the whole mass; whilst the inner one lines the canals which ramify through it. But instead of these two membranes being in contact, as are the horny sheath and the lining of the tubes in the Sertularians, a thick mass of flesh is interposed between them; and it is usually in this flesh, and not in either of the membranes, that the hard deposit takes place, which gives firmness and support to the general structure.

1090. The family we shall first consider, includes those species which have a *spongy* polypidom,—of which the *Alcyo-*

nium is a characteristic example. Here the general form and aspect closely resemble those of the Sponges; but, in the living state, it will be evident that the projecting orifices are tenanted by Polypes; and, even in the dry skeleton, it may generally be observed that the openings of the large canals are not simple, like those of the vents of Sponges, but present some indications of the radiating partitions already mentioned. Between the large canals, into which the Polype-stomachs open, there is a network of minute tubular ramifications, which connect them very intimately. In the interstices of these ramifications, which are occupied by the gelatinous flesh of the animal, *spicula*, or long needle-shaped crystals, of earthy matter are deposited; which, as in Sponges, give a general support to the whole mass, though not consolidated in any one point. The general vitality of the polypidom, however, would seem to be greater than that of Sponge. If a single Polype be irritated, it withdraws itself within its tube; and the edges of the cell, which were at first prominent, become nearly flat. If the irritation be more severe, several of the neighbouring Polypes also withdraw themselves; and if it be sufficiently prolonged, a collapse and contraction of the whole polypidom is evident. The analogy is very striking between this phenomenon, and that exhibited by the Sensitive Plant, in which the effects of the irritation are manifested at a greater or less distance, according to its intensity (VEGET. PHYSIOL. § 422). If, instead of the Polypes being irritated, a portion of the general surface be touched, a curious series of changes will take place. After some little time the part touched becomes opaque, more dense, and depressed; and,

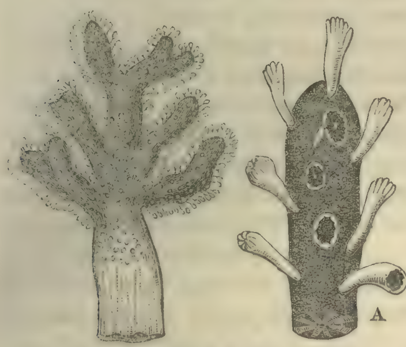


FIG. 621.—ALCYONIUM: A, portion enlarged, showing the Polypes.

if the stroke be severe, this contraction will extend through the whole mass, and the Polypes also will shrink. This is peculiarly evident if the vessel containing the animal be smartly struck; since the shock will then be simultaneously felt through the whole structure. Even the complete division of the polypidom with a sharp knife, does not produce so evident an effect as a slight shock, of which the effect is thus diffused. On the other hand, when at rest and undisturbed, the Polypes protrude their bodies, and unfold their beautifully-formed tentacula, and take in a large amount of water. This is transmitted through the whole interior of the polypidom by its anastomosing canals, and the mass becomes distended to twice or thrice its original size; and from being firm and opaque, it becomes soft and pellucid.

1091. The general integument of this spongy mass has a firm leathery texture, and sometimes contains a distinct calcareous deposit; as does also that continuation of it, which forms the external coating of the Polypes themselves. From the integument the *buds* are produced, which originate in the spongy structure itself, and are, in fact, prolongations of it. These are traversed by canals, that branch off from those of the parent mass; and resemble pieces of Sponge in every important particular. It is not until the Polypes are developed at the terminations of these canals, that the real character of the mass can be positively stated. This is another example, in addition to the number we have already seen, of the *progressive development* of the higher forms of organised beings; and of the correspondence between its several phases, and the forms which remain permanent in the lower parts of the scale.

1092. The form and dimensions of the various species of *Alcyonia* differ as much, as do those of the Sponges, to which they bear so great an external resemblance. The *Alcyonium digitatum* creeps along the surface of loose stones and shells, forming a thin fleshy crust, which rises up in irregular lobes or projections. This small species is so abundant on some parts of our own coasts, that scarcely a stone or shell can be dredged up from deep water, which does not serve as a support to one or more specimens of it. The particular form it presents, varies according to the

nature of the surface on which it grows. Sometimes it spreads out into finger-like projections; and hence has received from the fishermen the name of *Dead-man's-hand*. Other species attach themselves to rocks, and grow, like sponges, hanging down from the upper surface of submarine hollows in the face of overhanging cliffs. Others of still firmer texture stand erect beneath the shallow waters of the shore. Of this kind one of the most remarkable species, probably the largest *Alcyonium* at present existing, is the *A. poculum*, or Neptune's cup, which was discovered by Sir Stamford Raffles upon the Coral reefs that surround the Island of Sumatra. Many specimens, brought from the neighbourhood of Singapore, now exist in the Museums of this country; and among these, some have attained the dimensions of nearly three feet in height, and eighteen inches in diameter. Their affinity with the Sponges is drawn yet closer, by the *siliceous* character of the crystalline deposits, to which they owe their firmness; and, by some Naturalists, this species has actually been referred to the class Porifera.

1093. In the one family of this Order, the polypidom is unattached; and the animals are carried about by the action of the waves, having but little power even of directing their movements. Of this group, the *Pennatula*, or Sea-pen, is a charac-

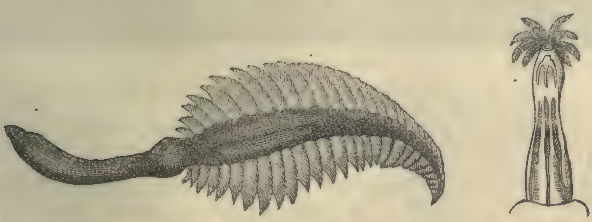


FIG. 622.—PENNATULA.

teristic example. It consists of an axis which is stony for a considerable part of its length, but is flexible at its two extremities. This is clothed with a flesh, which extends along the sides into pen-like prolongations, arranged like the barbs of a feather; and one edge of each of these is fringed by Polypes. The skin contains a large amount of calcareous spicula, and is

often deeply coloured; being, in the British species *Pennatula phosphorea*, purplish-red along the stalk, and orange at its extremities. It is not often that the Pennatulæ rise to the surface. They are usually brought up from considerable depths by fishing-lines; and the fishermen believe that they are generally fixed in the bottom, with their ends immersed in the mud. Some of the *Pennatulæ* are very brilliantly phosphorescent; and the appearance of the larger species, when displaying their luminosity in the dark ocean, is very striking. The disengagement of light is, however, by no means constant; but, as in all other instances of phosphorescence, depends upon the condition of the animal. When it is irritated or alarmed, a vivid emission takes place; but this soon dies away. When frequently struck by the waves, it is possible that they may continue the display with little interruption; but observation proves that, when preserved in calm water, they do not voluntarily disengage light,

although they readily show it if disturbed. The accompanying figure represents a genus of Alcyonian Polypes, nearly allied to the Pennatula.

1094. The next group of *Asteroid* Polypes includes many well-known species,—such as the *Red Coral*, the *Gorgonia* or Sea-fan, the *Antipathes* or *Black Coral*. In all of them the structure of the Polypes is nearly the same; and the differences of the polypidom chiefly relate to the portion, in which the solidification of the structure has taken place to the greatest extent. It will be recollected that, in the true *Alcyonia*, the calcareous or siliceous spicula are deposited, as in the Sponges, through the whole mass; and that, with the exception of the fibrous bands which interlace between the canals, no one portion

is harder than another. Now in the group at present under consideration, a solidification takes place in the centre or axis of the polypidom, and often in the integument also. Almost all the species included in it have an arborescent form; and so much does the flexible axis of many kinds resemble the stem of a plant, that, even so late as the year 1825, the celebrated Blumenbach writes—"The stems appear to be *really vegetables* (the woody nature of which in the larger ones cannot be mistaken) incrusted with corals."

1095. Among the *Gorgoniæ*, or Sea-Fans, there are some species which very closely resemble the Alcyonia, in the uniform distribution of the firm texture through their whole substance. In others, however, a firm horny skeleton is found, which is commonly known as the Sea-fan; and, in the living state, the flesh which clothes this is covered by a dense integument, containing an abundant deposition of calcareous particles. If the flesh be allowed to dry upon the stem, the integument remains as a friable crust, which may easily be peeled or rubbed off, disclosing the horny stem within. No mark of the habitation of the Polypes is ever found upon the internal axis; but the remains of the cells may often be observed in the integument, when dried over it. The dry form in which the skeleton of the *Gorgoniæ* is commonly known, does not give a correct idea of its real character; since, in the living state, there is by no means a complete isolation between the hard axis and the soft living flesh, but the one passes gradually into the other. On cutting across the stem, it is observed that it is formed by concentric layers, like those of a dicotyledonous tree; and it is probable that these are formed by the successive consolidation of the flesh in contact with its surface. Beyond this general analogy, however, no resemblance can be made out; since nothing like the intricate arrangement of dissimilar parts in a woody stem, can be found in these simply-organised but beautifully-formed structures. Whilst the axis of the *Gorgonia* is usually brown or black, its crust often exhibits colours of great brilliancy, especially in the living state; in some species it is of a deep red, in others of a bright yellow, and in others of a crimson hue.

1096. The structure of the *Antipathes* is by no means unlike that of the Gorgonia. The axis is still more firm, presenting when dry a smooth polished surface, which, joined to its dark colour, has caused it to receive the designation of *Black Coral.* The calcareous deposition in the integument, also, is still more abundant; so that the crust, when dry, is sometimes even thicker than the stem. The solidifying matter having thus entirely left the flesh, we find it extremely soft;—so soft, indeed, that when brought up from the depths of the sea, this substance runs off almost entirely, leaving the integument adhering to the axis.—In the *Corallium rubrum*, or Red Coral, the solidification of the axis has proceeded still further; for it contains not only horny animal matter, but a large quantity of calcareous particles, so closely deposited in every part, as to give great solidity to the stem, and to enable it to receive a fine polish when cut into fragments. This is a valuable article of commerce, and is principally obtained from the Mediterranean, where it is brought up from considerable depths. No vestige of polype-cells can be detected upon the surface of the axis. These are confined to the flesh and its integument, which are both very soft; the latter does not contain enough calcareous matter to make it perceptible as a crust when dried upon the axis. The density of the Red Coral renders it very brittle; and, did it not grow in a somewhat stunted form, it would be liable to

FIG. 623.—RED CORAL.

injury from the violent motion of the water in which it grows. —There is a very interesting species of this group, which connects in a remarkable manner the stony *Corallium* with the horny *Antipathes*. This is the *Isis Hippuris*, in which the stem is composed of both these substances alternately, so as to give it a jointed appearance. It is formed by the deposition of calcareous matter at intervals along the horny stem; and in this manner it is endowed with a considerable degree of flexibility. If the axis be submitted to the action of an acid, the calcareous deposit is removed; and its structure appears uniform throughout. Although its aspect is *jointed*, therefore, no real articulations exist; the flexible substance, of which the intervals are alone composed, being really continued through the whole. We may perhaps regard this as a kind of *sketch* of the Vertebrated structure.

1097. The last group of the Asteroid Polypes differs from those we have hitherto considered, in several important respects. In the *Tubiporidæ*, each polype is inclosed in a distinct cylindrical tube, which is formed by a continuation of its external membrane; and there is no communication among the individual members, nor anything like the gelatinous flesh or central axis of other Alcyonians. In some genera the tube is membranous, or somewhat horny; but in the *Tubipora*, the genus from which the order takes its name, it is of firm calcareous structure. Of this genus only one species, the *Tubipora musica*, inhabiting the Indian Ocean, is known. It takes its name from the regular arrangement of its cylindrical tubes by each others' side; whence it is commonly termed "Organ-pipe Coral." These tubes are of a dark and rich crimson; whilst the Polypes themselves have a bright green colour when alive; so that the contrast is very striking. The Polypes resemble those already described, in all the leading particulars; except that the living membrane, which lines their interior, does not seem to extend far down the calcareous tube; and the ova are developed, not from its folds, but from filaments prolonged from the base of the stomach, which hang down into the cavity. The calcareous tube is formed by the solidification of the membrane, which envelopes the Polype; and this is reflected in a funnel-shape, so as to close the mouth of

the tube, within which the Polype can be entirely withdrawn. The tube is gradually prolonged by the deposition of stony matter in this membrane, which is continuous with its upper edge; and the Polype always maintains its position at its extremity. At intervals, however, a sort of collar is formed around each tube; and as a number of Polypes usually grow in close proximity with each other, and form this collar at about the same time, an almost continuous horizontal partition or floor is thus constructed, which gives great additional strength to these delicate polypidoms. This collar is produced in the following manner. The membranous continuation of the tube, instead of growing straight upwards, makes a turn outwards, as if it were flattened-down all round. A double fold is thus occasioned, in which calcareous matter is deposited, and the collar is thus completed. From this point the membrane is prolonged in a straight direction as before, until the new impulse arises, which causes another floor to be constructed; and thus a succession of *stories* is built up.—The ova, when they issue from the parent, have little or nothing of their perfect form. They seem to fall upon a neighbouring portion of the floor, and there to begin the development of a tube, which grows up among the older ones. Thus it happens that, between every two floors, there are more tubes than in the division below; and the whole mass assumes somewhat of the form of an inverted pyramid.

ORDER IV.—CILIOBRACHIATA.

1098. The last order of POLYPIFERA differs so greatly from all the rest in its internal organisation, that it almost deserves to rank as a separate class. As the *Asteroida* connect the Polypes with the Sponges, so does this group form the transition to classes of much higher organisation. In general aspect and delicacy of structure, the Polypes of this order bear no inconsiderable resemblance to the compound *Hydraform* groups (§ 1052); and especially to the *Sertularidæ*, under which family many of them have until recently been classed. They are not known to occur

singly, but they sometimes present themselves in an almost isolated form; their cells arising separately from a creeping stalk. In other instances they are closely aggregated, as in the common *Flustra*, where they are spread out into an expanded surface; but they never seem to exhibit the same degree of structural connection, as that which exists in the inferior groups. In a large proportion of instances, the cells are of a delicate horny structure; and in those which are calcareous, the animal membrane remains as a much more definite tissue, when the stony matter has been removed by an acid, than in lithophyte corals of the other groups. As in the *Tubipora*, the wall of the cell is distinctly continuous with the membrane which closes the mouth of it; as this is with the external integument of the Polype itself. Moreover, the mouth of the cell generally possesses some flexibility, and is drawn inwards, so as to form a kind of *operculum* or lid to the cavity, when the Polype retracts itself within. The cells undergo remarkable modifications in form at different periods of age, even in the calcareous polypidoms. The polypidoms of this group never attain any considerable size; and they are almost always parasitic upon other marine formations, such as corallines, sea-weeds, shells, or even different species of their own tribe.

1100. The species, which has been most carefully studied and minutely described, belongs to that group in which the isolation of the Polypes is most complete; and it will, therefore, be convenient to enter first upon the consideration of its structure. The Polypes of the *Bowerbankia densa* are, when fully expanded, about half of an inch in length; when retracted, they are completely inclosed in delicate horny cells, so transparent as to admit of the whole structure being seen through their walls. These cells, which, when the edges are turned in by the retraction of the animal, are not above half the length of the expanded body, arise separately from creeping stems, which attach themselves to the *Flustra* in aggregated masses, of from half an inch to one inch in diameter. The animal possesses ten tentacula, arranged in the usual manner around the mouth; and each of these is thickly set with cilia on both sides. The mouth does not lead

at once, as in the inferior Polypes, into the stomach; but it forms the entrance to a wide funnel-shaped tube, which may be termed the *pharynx*. This soon contracts into a narrower canal, the *œsophagus*, which terminates at its lower end in the digestive cavities. The first of these is an organ which seems closely to resemble a *gizzard*. It is of a globular form, and has two dark spots upon its sides, from which radiating lines are seen. These are probably composed of muscular fibres, the office of which is to effect the trituration of the food, by means of the teeth that project from the inner wall of the cavity. The gizzard opens at its lower end into a larger bag, which seems to be the true digestive stomach. Its walls are thickly studded with spots of a rich brown colour; these appear to be caused by minute follicles or sacs opening from its cavity, in which *bile* is secreted for assisting the digestive process. A fluid is poured out from them which tinges the whole stomach, as well as its contents, with the characteristic hue of that secretion; and we may therefore regard these follicles as constituting the simplest form of hepatic gland or *liver*, which we meet with in the animal kingdom. It is easy for the comparative anatomist to trace the gradual concentration of these scattered elements, up to the consolidated form in which they present themselves in the highest grades of organisation (ANIM. PHYSIOL. § 356). From the upper part of the stomach, and by the side of the entrance from the gizzard, arises the intestine; the orifice of which is surrounded by vibrating cilia. This passes up as a straight tube by the side of the œsophagus, and terminates by a distinct orifice outside the circle of tentacula.

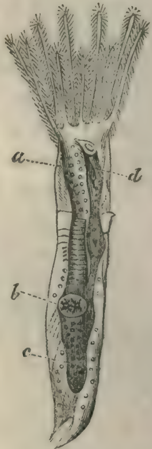


FIG. 624.—BOWERBANKIA. *a*, œsophagus; *b*, gizzard; *c*, stomach; *d*, orifice of intestine.

1100. The whole of this complex digestive apparatus floats freely in the general cavity, formed by the integument of the animal; the space between being occupied by a clear fluid, and

by the muscles which change the place of the animal in its cell. The cell is formed by the outside of this integument; of which the lower part is so consolidated by horny matter, as to be nearly unyielding; whilst the upper third remains flexible. This flexible part consists of two portions; the lower half being a simple continuation of the rest of the cell; whilst the upper consists of a row of delicate bristle-shaped processes, or *setæ*, which are arranged parallel with each other round the walls of the cell, and are prevented from separating beyond a certain distance, by a membrane of excessive tenuity, which surrounds and connects the whole. This mode of termination is very common in the cells of the *Ciliobrachiate* Polypes; and it is evidently a provision for allowing the freest possible motion of the upper part of the body in its expanded state, to which it affords at the same time support and protection; whilst it completely defends it when retracted or withdrawn into the cell, as will presently appear.

1101. For the purpose of *retraction*, two distinct sets of muscles are provided; one acting upon the animal, and the other upon the cell. The first set arises from the bottom of the cell, and is attached to different parts of the digestive tube. The second set arises from the upper part of the firm portion of the cell, and is attached to the flexible continuation of it. When the animal wishes to withdraw itself, the tentacula are first closed together into a straight line; and immediately the whole digestive tube begins to descend, its different parts being folded upon one another, and drawn back within the integument, which is inverted over them so as to form a close sheath around the tentacula. When the animal is completely retracted, the œsophagus is bent upon itself like the letter S; and the tentacula lie straight in its axis, inclosed in the inverted tube of integument, their extremities being on a level with the top of the unyielding portion of the cell. By the time that the end of the arms are on a level with the base of the *setæ*, the retraction of the latter commences. This is performed exactly in the same manner as that of the tentacula; and the flexible portion of the cell is inverted over them, so as to form a complete envelope.—

The protrusion of the body takes place by a contrary series of processes. The bundle of *setæ* first makes its appearance out of the apex of the cell, and is followed by the flexible portion on which it is set. The tentacula next pass up between the setæ and thrust them asunder ; while the integument is seen gradually rolling onwards from around the tentacula. These latter continue to emerge, and the integument to be inverted from around them, until the base of the tentacula has risen above the top of the expanded setæ ; when the act of protrusion is completed, the tentacula separate and expand, and the cilia commence vibrating. These actions are generally performed with an extraordinary rapidity ; and it is only when they are executed with unusual slowness, that the several movements concerned in them can be distinguished.

1102. Upon reviewing the complex organisation of this minute Polype, it must be admitted that its mechanical functions are executed with a degree of perfection, which cannot but excite our surprise and admiration ; and not less interesting is it to observe the other vital operations exhibited by it, which the transparency of the whole structure enables us to watch with no interruption. The little animal, when in full vigour, is seen projecting from its cell with the arms extended and the cilia in active operation ; the upper part of the body being frequently turned from side to side over the edge of the cell, the extremity of which, from its peculiar flexibility, moves along with it. The action of the cilia forms a kind of whirlpool, by which the particles contained in the surrounding water are carried into the funnel-like pharynx. By the contraction of its walls, they are carried rapidly down the œsophagus into the gizzard, which expands to receive them. Here they are submitted to a sort of crushing operation ; the movement of its walls very much resembling that, which is seen in the dental apparatus of the Wheel-Animalcules (§ 857). Their residence in this cavity, however, is only momentary ; and they are immediately propelled into the true stomach below, where they become mixed up with its contents, which, during digestion, are always of a dark rich brown colour, being tinged by the secretion of the biliary follicles

surrounding it. The food appears to be retained for a considerable time in the stomach, and may frequently be seen to pass back into the gizzard, for the purpose of being again submitted to its operations. After being subjected to the digestive process in the stomach, the particles which remain are transmitted into the intestine ; but previously to their entering it, they are seen to rotate for some time about its orifice, the movement being produced by the action of the cilia that fringe it. The granular matter accumulates in little pellets in the intestine; and when these pass out from its extremity, they are immediately whirled off to a distance, by the same action of the cilia upon the arms, as that which produces a current towards the mouth.

1103. Considerable power of *selection* appears to be enjoyed by these Polypes in regard to their food. The movements of the cilia which fringe the tentacula, seem entirely under the control of the individual ; and by their vibrations currents of water are produced, which bring particles of various kinds of living and dead matter to the entrance of the alimentary canal. It has been sometimes noticed that animalcules, which have thus been drawn into the pharynx, escape during the act of swallowing ; but they are usually met by one of the tentacula, which bends inwards, and by means of a sharp blow drives them back into the mouth. They do not immediately perish in the stomach, but may sometimes be seen to continue their movements for a considerable period within its cavity. Of the vortex which is drawn by the cilia towards the mouth, a considerable amount passes out between the bases of the arms ; and this usually contains the finer particles, which thus escape. Of those which remain within the cone, those of fitting size are received into the pharynx ; and, when they have passed downwards to its termination, a more perfect selection appears to take place, by which some are admitted into the stomach, whilst others are rejected. Besides this regular flow of water into the pharynx, the fluid is occasionally introduced in larger quantity, by the sudden dilatation of the tube, which quickly returns to its former diameter, and expels a large part of what it had thus taken in. This movement is not improbably connected with the function of

respiration. That a part of the alimentary canal should be specially modified for this purpose, is by no means surprising; for such a modification, in a somewhat different form, is not at all uncommon in various divisions of the animal kingdom. Thus, in the lowest group of Mollusca, to which these Polypes bear considerable affinity, we have seen that the entrance to the stomach lies at the bottom of a large cavity lined by the respiratory membrane, over the walls of which currents of water are constantly passing, which supply the digestive organs with alimentary materials, besides effecting the aeration of the blood (§ 974).

1104. As in the two preceding Orders, we meet with species among the Ciliobrachiate polypes, which have the power of forming stony cells, by a deposit of lime in their soft tissues. The cells of some of these polypes are covered-in, when the animal is withdrawn, by a sort of lid or flap, which is provided with muscles for drawing it down upon the mouth of the cell. In others of the compound polypidoms, however, the cells overlap one another obliquely; and the orifice is not at their extremity but rather on one side, so that the operculum has only to be slightly upraised, to allow of the protrusion of the animal. This is the case in the common *Flustra* of our own coasts, which presents a flat expanded surface, so thickly set with these apertures, as to appear like a delicate network. These *Sea-mats*, as they have been fancifully termed, so much resemble common seaweeds in their general aspect, that they are often mistaken for them by ignorant collectors. They may readily be distinguished, however, by the *crispness* of their feel, when contrasted with the flabbiness of the Algæ, as well as by the polype-cells so beautifully arranged on their surface. The extension of these compound structures takes place by buds which are developed from the outer surface of the cells. From one original cell of the Flustra, five such buds may be sent off, which develope themselves into new cells around it; and these, in their turn, produce buds from their unattached margins, so as rapidly to increase the number of cells to a very large amount. This extension may go on almost without limit; and it often happens

that the cells in the centre of a leaf-like expansion of the Flustra are devoid of polypes, and have lost their vitality, whilst the edges are in a state of active growth. Although this mode of multiplication appears to be the one most characteristic of the group, the production of gemmules or ova occasionally takes place, as in other Polypifera. These are developed from the lining membrane of the cell, and gradually increase so as to fill up its cavity, and to cause the death of the contained polype. When mature, they escape from the cell, and swim about for some time, after which they fix themselves, and lay the foundation of new structures.

1105. The polypes forming these compound structures are usually packed closely together; and are of very minute size;

FIG. 625.—PLUMATELLA : *a*, natural size ; *b*, a group enlarged ; *c*, anal orifice.

so that a single polypidom of very moderate dimensions must contain an enormous multitude of individuals. Dr. Grant has reckoned that, on an ordinary specimen of *Flustra carbasea*, there are about ten square inches of surface; in each square inch there may be about 1800 polype-cells, thus making altogether 18,000 within this small space. Each of these polypes has 22 tentacula; so that there will be about 396,000 of these minute arms

upon this little specimen. If each of these tentacula has only 100 cilia upon its edges (and there are probably many more), the whole polypidom will have 39,600,000 of these minute but important organs. Other species certainly contain more than ten times these numbers. Dr. Grant has computed about 400,000,000 cilia to exist on a single *Flustra foliacea.* In the *Alcyonella*, a fresh-water species composed of long membranous cells arranged side by side so as to form a spongy mass, the number of *tentacula* on a moderate-sized specimen may be computed at nearly five millions and a half; and the *cilia* are certainly not less than a hundred times that number. The figure in the preceding page represents another very beautiful fresh-water polype of this Order, which is by no means uncommon. It is found upon the surface of leaves, &c., of aquatic plants.

1106. From the very imperfect degree in which the greater part of the polypes of this group have been yet examined, the subdivisions of it are at present necessarily founded only upon the arrangement of the cells in regard to one another. Such an arrangement is liable to this great objection, that the mode in which they are disposed will vary extremely with the surface upon which they grow. Hence it is not advisable for us to enter more particularly into the classification of this group; but the study of it may be especially recommended to those who have opportunities at their command, as a most interesting pursuit, which, with but a moderate amount of previous information, and of skill in observation, is sure to be productive of much that will be alike interesting, novel, and important.

1107. The most extended survey we can take of the operations of the Polypifera upon the surface of the globe at the present time, will give us but a very inadequate idea of the important part which they performed, in the remoter epochs of the history of the earth. Our wonder is excited when we hear of a continuous reef of coral more than a thousand miles in *length;* yet what is this to the formation of limestone strata, covering *superficial areas*, not only of thousands, but of tens of thousands, of square miles, to a thickness, in many instances, of

3000 feet? Yet the Geologist of the present day has little hesitation in regarding these formations, as having taken their origin from the labours of these apparently-insignificant and simply-organised beings. As at the present time, the greater proportion of these structures appears composed of the *Lamelliform* corals (§ 1069); but the remains of Alcyonian polypes are by no means unfrequent in the limestone rocks, and are especially abundant in particular strata; and some of the harder forms of the *Ciliobrachiate* group are occasionally found.

1108. There are many instances in which the Coral structures of comparatively *recent* origin have undergone a metamorphosis, which causes them to lose, in greater or less degree, their original aspect. Large masses, when long exposed to the air, become changed into a solid, often somewhat crystalline, rock; in which the traces of organic structure are very indistinct, and with which the *Mountain* or *Secondary Limestone* closely corresponds. This is observed in the Bermudas,—a group of islands, which seems to have been for the most part formed by Coral Polypes of the same species with those now existing in the seas around.—Moreover, the Coral Sand, formed by the action of the waves upon the living structure, often becomes consolidated into a hard stone by the filtering of water through it; a small quantity of the carbonate of lime being probably dissolved at the surface (where the carbonic acid of the air increases the solvent power of the water), and set free again below, so as to glue together the separate particles. It is in such a mass, that the human skeleton is imbedded, which was found on the shore at Guadaloupe, and is now placed in the British Museum. This stone, when minutely examined, is found to consist of a number of rounded grains, cemented, as it were, together; and it closely resembles the rock known to the Geologist as *Oolite*.—Further, where shallow water exists around Coral islands, the bottom is found to be covered with a layer of white mud, which is formed by the decay of the animal matter that held together the particles of carbonate of lime in the stony corals; and these, being thus set free in a finely-divided state, fall to the bottom in a form which, if dry, would constitute *Chalk*. Thus we may

trace very distinctly the mode in which three principal kinds of limestone rocks may have taken their origin from Coral formations.

1109. Now, the *Mountain*, or *Carboniferous Limestone*,—a rock very abundant in Britain, extending over large areas beneath the coal-fields, and sometimes exhibiting a thickness of nearly 3000 feet,—though in some parts evidently composed of accumulations of Shells, Encrinite stems, &c., exhibits the Coral structure very distinctly in many situations; and these parts are so blended with the neighbouring rock, as to make it appear probable that the latter also was once in the state of coral, but was gradually changed by the process just described. Further, the collections of other animal remains are such, as we should expect to find on the margin of a coral reef or island existing at that epoch; and a similar process of fossilization is taking place at this very time, on the shores of the islands now being built up,—the species of animals imbedded being, however, not the same. The great thickness of the beds of this rock may be very well accounted for, in the same manner as the depth of the coralline masses of recent formation (§ 1077). The *Oolite* had its origin in the wearing-down of the older limestone beds, with additional matter derived from the skeletons of the races of animals, which existed during the period of its formation. And there can be little doubt that the *Chalk*-formation owes a considerable part of its substance to the same sources; though part was doubtless derived from the decomposition of shells, and a large proportion in some situations from the remains of animals of extreme minuteness, presently to be described (§ 1107).—There are observed, in rocks of more recent formation, appearances which still more clearly indicate, that they too were originally formed by Coral-polypes. These are often found within narrow limits, as if they had been reefs or islands of small size. Thus we find a stone, called *Coral-rag*, in Oxfordshire; and very distinct Coral-beds in the *Crag* of the eastern coast of England. It is interesting to remark, that the remains of Coral, which are found in the older limestones, all correspond with those at present abounding near the equator, and exhibit the *Lamelliform* structure (§ 1069); whilst they are

gradually replaced in the newer strata, by species more allied to those at present existing in temperate climates. This is one of the many facts, which tend to prove that this part of the earth had, at some former period, a much higher temperature than at present.

1110. Under the class Polypifera, we are probably to include a large and very important group of minute calcareous structures, which, from their strong resemblance to the spiral-chambered shells of some Cephalopoda (§ 894), have been supposed to be formed by animals of that class. Many kinds of them exist on almost every sandy shore; but their extreme minuteness causes them to be usually overlooked, and is also an obstacle to the satisfactory determination of the character of the animals which construct them. By D'Orbigny, who first attracted the attention of Naturalists to the details of this curious group, it was regarded as an order of Cephalopoda; and he gave to it the name of *Foraminifera*, on account of the communication between the chambers not being established by one principal tubular aperture, the *siphuncle*, but by numerous minute foramina or porous orifices. The species which exist on the shores of Northern Europe are so minute, as not to be easily examined, even with the microscope; but those which are found in the Adriatic Sea, are sufficiently large to be recognised with the naked eye. From an examination of recent specimens, it has been ascertained that the animals by which these shells are constructed resemble polypes more than any other group, although allied also to the Polygastric Animalcules; and that we are thus to regard these little isolated masses as coralline structures, each being formed by the continual growth of one individual. The character of the animal appears very simple. No part of it is seen externally, except when it is preparing to add a new chamber to its shell. It seems to consist of a series of membranous bags, united together like a string of beads, in the outer layer of which is deposited the calcareous matter that gives the shell-like character. If this latter be removed by a weak acid, the animal membrane will be left; and the spiral may then be unrolled. Whether any of the species possess a regular mouth and tentacula, is yet uncertain.

1111. If we merely consider this group as it presents itself to our notice in the existing epoch, we should have but a very imperfect idea of its importance. The forms under which it once existed in much greater abundance, have been preserved to us; and recent inquiries have added to our knowledge of these in a most astonishing degree. The fossils termed *Nummulites* have long been observed to bear a large share in the formation of extensive beds of limestone rock. They were remarked by Strabo in the stones of the Pyramids; and he informs us that they were commonly reputed to be the petrified impressions of the lentils, which had been used as daily food by the workmen engaged in building them, and takes some pains to refute this idea. By subsequent authors, these Nummulites have been supposed to be the *opercula* (§ 902) of the Ammonite (§ 897), which, it was imagined, might probably form a new one, every time that it added a chamber to its shell. The discovery, however, of minute shells of a similar character at present existing, and evidently belonging to distinct animals, established their claim to a similar position. Nummulites are probably the largest forms of this group, of which D'Orbigny has described fifty-two genera, and above 600 species; some of them measure about an inch and a half in diameter, whilst a great proportion of the rest are microscopic. Many limestone strata of the tertiary period, are almost entirely composed of the larger Nummulites; and these strata constitute the principal part of several mountain ranges in Southern Europe, such as the Alps, Carpathians, and Pyrenees. The Sphinx, as well as the Pyramids, are composed of a limestone loaded with Nummulites.—A more minute shell, the *Miliola*, of the same description, but no larger than a millet-seed, bears an equal proportion in the mass of limestone strata which are quarried near Paris. "We scarcely condescend," observes Lamarck in reference to this fact, "to examine microscopic shells, from their insignificant size; but we cease to think them insignificant when we reflect, that it is by means of the smallest objects that Nature everywhere produces her most remarkable and astonishing phenomena. Whatever she may seem to lose in point of volume in the production of living bodies,

is amply made up by the number of the individuals, which she multiplies with admirable promptitude to infinity. The remains of such minute animals have added much more to the mass of materials which compose the exterior crust of the globe, than the bones of Elephants, Hippopotami, and Whales."

1112. But these facts sink into insignificance, when compared with those lately revealed by the researches of Ehrenberg, in regard to the existence of a race still more minute, and its multiplication to a still more inconceivable extent. In examining, with a high magnifying power, Chalk or Whiting in a state of extremely minute division, two sets of particles may be distinctly seen; one set having a crystalline structure, and the other presenting some indications of an organic aspect. If these be rendered more transparent by the use of Canada balsam, it is seen that they are *polythalamous* (many-chambered) shells of great minuteness; some of them in fragments, and others nearly or quite perfect. The size of these varies from $\frac{1}{24}$ to $\frac{1}{288}$ of a line; and when, as in the Chalk of Southern Europe, they constitute nearly the whole mass, there must usually be above a million in every cubic inch. In the fourth part of a cubic line, or $\frac{1}{12}$ of a grain, from 150 to 200 can be ascertained to exist; and thus there would be from 1800 to 2400 in each grain, and far above ten millions in every pound of chalk. In the chalk of this country, and of other parts of the north of Europe, there is a predominance of particles of a somewhat crystalline character; but even these have in all probability once been combined in organic structures. In pursuing his researches on this subject, it occurred to Ehrenberg to examine the finer particles of calcareous matter, which have been artificially separated from chalk, and are employed for various purposes. Of such, the *glazing* of the papers with which the walls of apartments are sometimes covered, and that of visiting cards, are partly composed; and on scraping a little of this, and subjecting it to microscopic examination, he was delighted to find the organic structure almost everywhere apparent.

CHAPTER XXV.

OF THE CLASS OF POLYGASTRICA.

1113. The next class we shall consider is that of Polygastrica; which includes the simpler kinds of Infusorial Animalcules. Its true place in the Animal scale cannot be satisfactorily assigned, until the internal organisation of the beings composing it has been more thoroughly examined. At present, the general simplicity of their character, and the absence of any other decided type, leads us to rank them among the Radiata; although few of them present any distinct indications of the radiated conformation. This class was formerly supposed to contain the simplest members of the Animal Kingdom; many tribes belonging to it having been imagined to obtain their nutriment, by direct absorption from the surrounding fluid. It is now known, however, through the researches of Ehrenberg and others, that most of these possess an organisation of much greater complexity, having a distinct mouth (usually surrounded by a fringe of cilia), and internal cavities for the reception of food.

1114. Wherever any decaying organised matter exists in a fluid state, and is exposed to air and warmth, it will speedily be found peopled with minute inhabitants, of the most varied forms and diversified movements, possessed of considerable activity, and evidently endowed with an energetic system of nutrition. They are, therefore, by no means so nearly allied to Vegetables, as are those inactive and simple creatures—the Sponges and their allies. The cause of the spontaneous appearance of these Animalcules, where no germs were previously suspected to exist, and where it was not easy to suppose that they had been conveyed, has been a matter of much speculation. Many have had recourse to the supposition that the germs formed part, in a latent state, of the living tissues of the animal and vegetable structures, from

the decomposition of which they were evolved; and others have even supposed them to have arisen from accidental combinations of inorganic elements. As yet, however, somewhat of the same obscurity hangs over their origin, as envelopes the propagation of the Fungi; since there is some reason to believe that amongst the Polygastrica, also, the same germ may be developed into different forms, according to the character of the infusion from which it derives its support. But these Animalcules are not confined to infusions of organised matter; they are found in the stagnant waters around our cities; in the waters of rivers, harbours, and lakes; and even, it is believed, in every fluid drop of the ocean. From their minute size and almost universal distribution, therefore, we cannot doubt that they are by far the most numerous living beings, which exist on the face of the globe. Indeed, from the calculations which will be hereafter given (§ 1132), it would appear that a single cup of water may easily hold a number of the smallest known species, far surpassing that of the whole human population of the earth. And the ideas we form of their present amount seem mean and insignificant, when we contrast them with those, to which we are led by the contemplation of the fossil remains of those of former epochs (§ 1130).

1115. The forms presented by these Animalcules are extremely various. In some we can scarcely detect any definite

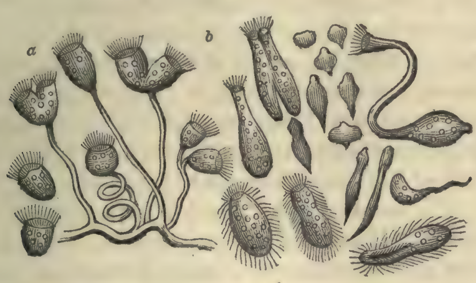


FIG. 626.—VARIOUS FORMS OF ANIMALCULES.

shape; their bodies appear composed of a mass of gelatinous matter without any solid support, which may project itself into

almost any figure. In others there is still considerable variety in the forms assumed by the same individual under different circumstances (Fig. 626, *d*); but still a prevailing shape can be recognised. In others, again, the body, although still unprotected by any firm envelope, appears to undergo little change in figure, except when affected by some temporary pressure. But there are many species which cannot be influenced even by this; their soft bodies being enclosed in a delicate but firm integument, strengthened by a deposit of siliceous matter. These are termed *loricated* Infusoria; and these envelopes, which are often preserved after the death of the animals, are termed the shields or sheaths.

1116. Although most of the Polygastrica have the power of freely moving through their native element, some occasionally attach themselves to a solid base, like Polypes; but many, like the *Hydra* and *Sea-Anemone*, have the power of occasionally detaching themselves, and go in search of a new field for the supply of their voracious appetites. The analogy to the Polypifera is very strongly marked in some species, however; in which we not only observe the Animalcules attached during nearly the whole of life, but find a large number associated into one plant-like structure. In almost all the Polygastrica, we find the body furnished more or less abundantly with *cilia*, which serve various important purposes. Sometimes they are only disposed around the mouth, towards which they produce a vortex of fluid, that brings a supply of alimentary particles. Where the digestive cavity has a separate termination, this also is usually fringed with cilia, by the action of which the particles rejected are thrown off to a distance. And, in many of the higher species not enclosed in a siliceous envelope, the whole body is beset with rows of these little filaments; by the action of which every possible variety of movement seems to be produced.

1117. The name *Polygastrica* has been applied to these Animalcules by Ehrenberg, in consequence of his belief that they possess a large number of distinct stomachs, or cavities for the reception and digestion of aliment. This belief is founded on the appearance which many of them present, when they have been allowed to remain for a short time in water, in which finely

divided particles of colouring matter are suspended. The particles are observed to be drawn towards the mouth, by the action of the cilia with which most of them are provided; and before long, the whole of the transparent body is seen to be studded with coloured globules of an uniform size, many times larger than the separate particles themselves. Sometimes these globules are very numerous, amounting to more than one hundred. If two kinds of colouring matter be put into the water, as for instance carmine and indigo, separate pink and blue globules will be seen in the bodies of some of the Animalcules. In many species, there is evidently a second orifice communicating with the interior of the body; by which a part of the colouring matter, and other substances taken in by the mouth, is afterwards rejected.

1118. From these facts it has been inferred by Ehrenberg, that a large number of globular cavities exist in the substance of the body, into which the food is received. He considers that sometimes these communicate only with the mouth, as in the *Monas;* but that in general they are arranged along an intestinal tube, into which they open by a short neck. The course of this tube he infers from the disposition of the coloured globules, rather than from any more distinct indication of its presence. Thus in the *Vorticella*, he thinks that it returns to the neighbourhood of the mouth; whilst in *Euchelys* and *Leucophrys* it terminates at the opposite extremity of the body,—running straight in the first from one end to the other, and in the second making two spiral turns in its passage. He does not affirm that he has ever distinctly seen food passing along this narrow intestine; or that he has been able to trace the walls of the globular stomachs, any more than of this alimentary tube, when they are not filled out with colouring particles. And his account of them, therefore, can scarcely be regarded as free from doubt.

1119. The views of Ehrenberg have not been by any means universally received amongst Naturalists; and many of those who have paid most attention to the structure and habits of these Infusoria, are of opinion that they are very erroneous. A kind of circulation has been seen to be performed by the globular

masses already mentioned, as if they floated loosely in the cavity of the Animalcule, and did not form part of the supposed alimentary canal. And it has been found that, when a small quantity of an alkaline solution is allowed to touch their bodies, they burst, and discharge these globules, which seem to have been imbedded in a soft gelatinous substance. Some of the globules appear as if entirely composed of the particles on which the animal has been feeding; and they have probably derived their globular form, from being moulded (as it were) in a little cavity behind the mouth. They are, for the most part, of very uniform size in the same species of Animalcule. But others have all the character of Cells; and it may be questioned whether they do not perform, in the economy of the Animalcule, the same purposes as the cells which float in the nutritious fluids of higher animals.—The whole subject of the nature of the organisation and life of these Animalcules, is still enveloped in great mystery, notwithstanding the extraordinary discoveries of the last few years. Some Physiologists doubt whether the greater number of them are to be regarded in any higher light than as single cells, not possessed of any consciousness or will, and having the same kind of power of movement as that which is possessed by those Epithelium cells which are furnished with cilia,—these, when detached from the surface on which they lay, being often seen to move in fluid for many hours. The Author does not at present feel himself able to express a decided opinion upon this interesting question.

1120. Putting aside the undetermined question of the interior organisation of the digestive apparatus, we may pass to the consideration of other phenomena presented by this remarkable class. Food is usually conveyed to the mouth by the vibration of the cilia which surround it; in this manner a vortex is produced in the fluid, which brings the particles floating in it, or other Animalcules swimming in its neighbourhood, within the grasp of the lips of that aperture. Sometimes even very large substances (in proportion to the size of the individual) are entrapped and swallowed in this manner; many species having much of the voracious character of the Sea-Anemone,

and swallowing entire the bodies of the Animalcules not very dissimilar to themselves,—to receive which the entrance to the digestive cavity has to undergo a distention, that very much alters their general form. In one genus, *Nassula*, there is a very curious dental apparatus, for the prehension and reduction of food. This consists of a sort of cone, formed by a large number of diverging flexible bristle-like organs, at the apex of which the mouth is placed, whilst the base can be projected and expanded so as to inclose the prey, over which it then contracts by the approximation of these curious teeth; these, although flexible, appear to possess considerable firmness.

1121. It is to the cilia, also, that the movements of the greater part of the Animalcules, which freely swim through the water, appear due. These movements are extremely various in their character in different species; and when a number of dissimilar forms are assembled in one drop of water, the spectacle is most entertaining. Some propel themselves directly forwards, with a velocity which appears (when thus highly magnified) like that of an arrow, so that the eye can scarcely follow their movement; whilst others drag their bodies slowly along, like the leech. Some make a fixed point of some portion of the body, and revolve around it with great rapidity; whilst others scarcely present any appearance of animal motion. Some move forwards by an uniform series of gentle undulations or vibrations; whilst others seem to perform consecutive leaps, of no small extent compared with the size of their bodies. In short, there is no kind of movement, which is not practised by these Animalcules. They have evidently the power of steering clear of obstacles in their course, and of avoiding each other when swimming in close proximity. By what kind of sensibility the wonderful precision and accuracy of their movements is guided, is yet very doubtful. The general surface, in those whose bodies are not inclosed in a firm envelope, appears very susceptible of impressions. No organs of special sensation, however, can be detected; except certain red spots observable in the bodies of many species, which are believed by Ehrenberg to be eyes. This belief rests only upon an analogy which may very

possibly be unfounded. There can be little doubt, from their position and their similarity to the undoubted visual organs in the class nearest allied to them, that the red spots on the neck of the Rotifera (§ 857) may be fairly regarded as eyes. But the same arguments by no means hold good in regard to the Polygastrica.

1122. Light has certainly, however, a considerable influence on these Infusoria, both in regard to their first production, and their subsequent movements. It has been found that they will appear much more speedily in an infusion exposed to light, than in one secluded from it. But there are some species which can exist in almost total darkness; being found in the recesses of the deepest mines. And it is further observed, that a very powerful light is injurious to them, and that they seek to avoid it; this may be due, however, to the *heat* which accompanies it, of the influence of which they are very susceptible. The greater number are instantaneously killed by a moderate heat, which acts equally upon both ova and adults; but they can support it better if the temperature be raised gradually. There are a few species which can support a temperature of 120°. On the other hand, *cold* is very injurious to these Animalcules; but it affects the adult more than the germ. If the water in which they exist be suddenly congealed, they are usually killed within two hours; but they are at first able to develope heat enough to prevent the freezing of their own bodies, as appears from the small quantity of water which remains fluid around them. If the congelation be gradual, however, they retreat beneath the surface, so as not to be included in the coating of ice; and in the winter, therefore, we meet with them just below the frozen covering of the waters which they inhabit. Even if they are entirely inclosed, and the greater part of them destroyed, it is seldom that one or two individuals do not remain,—the eggs being preserved where the parents have perished; and from these a new population, as great as the previous one, will speedily originate (§ 1123) at the return of the genial warmth which calls them into active life.

1123. The presence of Oxygen in the atmosphere, with

which the water they inhabit is in contact, is necessary to the continued life of Animalcules. But this may be in very small amount. Many species will live in water placed under the receiver of an air-pump, from which the greater part of the air has been removed. Others are not killed for a long time, by the interposition of a stratum of oil between the water and the air above. The microscopic observer well knows that he can keep most kinds of Animalcules for several days in a drop of water, flattened between two pieces of glass, so that it is only in contact with the air at its edges. But if some other gas be substituted for atmospheric air, a positively injurious effect results; when a vessel was three-parts filled with water containing Animalcules, and the remaining fourth was filled with hydrogen, they died within seventeen hours.

1124. Animalcules are very susceptible of the influence of Electricity. A spark drawn through water inhabited by them, usually destroys all those that happen to be in its current; and this is the case whether the Electricity be generated by an electric machine, by a galvanic pile, or by a magnetic apparatus, provided that the current be of sufficient intensity to decompose water. These beings are also readily acted upon by various substances, which are soluble in water, or which can otherwise act upon them in a fluid form; but the susceptibility to such influences varies with the species. Thus Animalcules inhabiting fresh-water are killed by a single drop of sea-water, which may nevertheless be full of other species peculiar to it. Alcohol usually destroys the inhabitants of fluids to which it is added even in small quantities; sugar has the same effect on many species; and strychnine on all. On the other hand, substances which are only mechanically suspended, or but slightly soluble in water, such as arsenic, appear to have little or no influence, even when their particles are swallowed; and calomel, corrosive sublimate, and camphor, are not fatal until some hours have elapsed.

1125. The universal presence of Animalcules in fluids containing organic matter, and exposed to the air, joined to the suddenness of their appearance under particular circumstances, has led to the belief that they are generated by the decomposition

of the animal or vegetable particles, which thus consisted, as it were, of their latent germs. But this hypothesis is unnecessary to account for the phenomena ordinarily observed; and it is inconsistent with ascertained facts. It does not appear that the Polygastric Animalcules are usually capable of retaining their vitality when dried up, as some of the Rotifera are known to do (§ 859). But it is unquestionable that their ova or germs are susceptible of this treatment without injury; and in this manner they are probably carried about, in the form of minute particles of dust, ready to develope themselves in any spot which may afford them the requisite moisture and nutriment. In this respect they probably resemble the Fungi, whose germs are known to be thus diffused (VEGET. PHYSIOL. § 50—64).

1126. The extraordinary powers of reproduction possessed by these Animalcules, will fully account for their rapid multiplication, when once they have obtained the means of development. Several modes of propagation are observed among them. Not unfrequently we observe, as in the *Vorticella* (§ 1128), a reproduction by buds developed from the side of the body, as in the *Hydra*. In other species, again, the process of generation is accomplished by the separation of the body into two parts: the division, which may be observed in several stages of its progress, is sometimes transverse (Fig. 626, *b*), sometimes longitudinal (*c*), sometimes oblique. In other tribes propagation takes place by ova or germs evolved within the body of the parent, the greater part of whose bulk is often made up by them. By these methods, sometimes employed singly, occasionally in combination, a single individual may soon become the parent of an immense population. Thus the *Paramecium aurelia*, if well supplied by food, has been observed to divide itself every twenty-four hours; so that in a fortnight, allowing the product of each division to multiply at the same rate, 16,384 animalcules would be produced from the same stock; and in four weeks, 268,435,456 new beings would result from a continued repetition of the process. But this animalcule has occasionally been observed to increase with much greater rapidity; the first million being produced (according to calculation based on fair data) within seven

days. But even this is as nothing to the more recent statement of Ehrenberg, that some species are sufficiently fertile to produce in four days 140,000,000 from a single germ; a number sufficient to compose, by the aggregation of their minute siliceous shields, two cubic feet of solid rock like the Polierschiefer of Bilin (§ 1132).

1127. The *classification* of the Polygastrica proposed by Ehrenberg is principally founded on his views in regard to the alimentary canal; and, until these shall have been established, it cannot be regarded as valid. For this reason it seems undesirable to introduce its details in this place; but a few of the more important groups, which are separated from one another by evident characters, may be here noticed. It is interesting to remark, however, that nearly every one of the subdivisions founded upon the arrangement of the digestive organs, may be further divided into two groups; one characterised by the presence, and the other by the absence, of a firm envelope or sheath, the existence of which becomes evident when the animalcule is compressed between two pieces of glass.

1128. The *Monads* constitute the smallest, and perhaps the simplest, of the Polygastric Infusoria. They usually present a spherical form; and seem like moving points of gelatinous matter. They swim freely and with activity, apparently by the vibrations of a sort of filament, which is said to be tubular. The number of coloured particles seen in their bodies, when the fluid in which they live has been tinged for the purpose, is usually small; in many species never above four or six. They only seem to possess one orifice to the digestive cavity; and from their extreme minuteness no cilia can be detected in its neighbourhood, though it is probable that such exist there. Of the Animalcules included in this family, some have a tendency to aggregate themselves in clusters; and it is probable that those which thus unite pass the earlier part of their lives in a separate condition. It is often very difficult to distinguish the *Monads* from the young of other species, which they much resemble. Where a number of minute gelatinous points are seen in the neighbourhood of clusters of larger forms, they are probably to be regarded

as their germs in a state of development. The Monads propagate both by subdivision, and by the production of ova. The former takes place either into two parts, by a transverse line of separation ; or into four by a crossed division.

1129. The next family to be noticed is that which contains the *Volvox* and its allies. The nature of these beings was, until recently, quite misunderstood. The *Volvox globator*, commonly found in ponds, has a spherical form ; and its diameter is as much as $\frac{1}{30}$ of an inch, so that it is easily discovered by the unassisted vision. This sphere, when examined with a high magnifying power, is seen to consist of a thin transparent pellicle, studded at regular intervals with minute green spots. Further examination makes it evident, that each of these spots is an individual animalcule of the nature of a Monad. From every one of these, two filaments proceed, which pass through the general envelope, and vibrate in the surrounding fluid ; so that, the whole surface of the sphere being beset by them, it is made to perform very active movements. It is usually seen rolling over and over like a ball ; sometimes spinning in the same place, like a top ; or gliding along smoothly, without turning itself. Sometimes its motions are slow ; at others rapid. The general envelope is traversed by canals, which seem to connect the different individuals together ; in the same manner as the Polypes of a *Sertularia* (§ 1056) are united by their common circulation. Within the parent sphere may generally be seen other globes of darker colour, and varying in number from one or two to twenty. These are young formations of a similarly-compound nature. They appear to have taken their origin from the subdivision of one of the Monad-like beings, which enter into the composition of its parent ; and for some time they remain attached to its inner wall. They afterwards detach themselves, however, and may be observed revolving in its cavity, by the action of their own ciliary filaments. After a time the parent globe bursts, and the young ones swim forth, and speedily undergo the same changes. Their dark colour appears due to the closer approximation of these component Monads ; the transparent *polypidom*, for so it may almost be termed, being developed between them at

a subsequent time. Not unfrequently a second generation may be observed within the globes still contained in the parent structure; and, with a good light, a third generation within these again. The animals of this family do not always form, by their aggregation, a globular structure; but are sometimes united in flattened clusters of various forms.

1130. The family of *Bacillariæ* is a very interesting one, since it includes nearly all the Animalcules, whose fossil remains (Fig. 627) have yet been discovered. A large number of the species composing it were formerly regarded as belonging to the vegetable kingdom; and, even now, considerable doubt may be entertained as to the claim of all to be regarded as Animals. This claim seems to rest more upon their general organisation, than upon the movements they exhibit; for the latter are very slight, and not distinctly referable to spontaneous action. In the greater number of species of this order, we find the body inclosed in a siliceous sheath of considerable firmness; sometimes, however, the envelopes are simply membranous; but no other mineral matter than silex has ever been detected in them. Their forms are extremely various. Most of them are elongated, like the *Navicula*, whose siliceous sheath has somewhat of a prismatic form. It has six openings, two at each end, and two in the centre, the latter being the largest. Through the latter it would appear that food enters the body. That there is an internal digestive cavity, is made apparent by the accumulation of colouring particles, which the transparency of the siliceous shield allows to be distinctly seen. Along the sides of the body are seen dark masses, which appear to be the organs for the evolution of ova; and the germs are said to escape from these, through the apertures at the extremities. There is much uncertainty, however, as to the vital actions of these beings. Many of them have a tendency to aggregation; and thus very curious forms result.

1131. The *Vorticellinæ* are a very interesting family to the Microscopic observer, from the variety of their forms and actions, and from their great abundance in most pools in which vegetation is going on. The ciliary action is here very distinct and

powerful; and the Animalcules show by their movements a great susceptibility to external impressions. Thus, the common *Vorticella* (Fig. 626, *a*), which clusters round the stalks of duckweed, is usually attached by a long peduncle, which, when the animal is seeking for its prey by the vibration of its cilia, seems fully extended, and almost put on the stretch. But if the stage of the miscroscope be smartly tapped, the Animalcule is seen to contract its peduncle suddenly; and it afterwards slowly extends it when free from alarm. In the *Stentor* (Trumpet Vorticella), which is one of the largest of the Polygastrica, the body is itself prolonged, and attached at its basis. In general these Animalcules have the power of separating themselves from their attachment, retracting the foot into the body, so that no appearance of a peduncle is seen, and then swimming freely in search of a new point to which to fix themselves. Some of them produce buds from their sides, like the Hydra; and others multiply by subdivision. Both these processes take place, if the temperature be genial, and the animals be well supplied with food, with great rapidity. By the older observers, those which were seen during their change, and whose form was thus very different from the one usually observed, as also those that were seen in their unattached condition, were regarded as distinct species. Errors of this kind have been by no means uncommon in Natural History, and will always be committed whilst observers are content with the cursory inspection of external forms, and do not make the changes, which these forms may undergo in the progress of life, an object of special study. In some genera belonging to this group, we observe the stalks of a number of individuals proceeding from one common stem; and sometimes this ramifies and subdivides, so as to exhibit a completely arborescent form, analogous to that of the Polypifera. The circular arrangement of the cilia around the mouth, and the mode in which these organs are employed in obtaining food, has occasioned the *Vorticellæ* and the Wheel-Animalcules to be confounded together.

1132. The almost universal diffusion of this class of Animalcules is not the least astonishing part of their history. There is

scarcely any situation, in which we cannot find some traces of their existence. Although they may be found, with the most certainty, in infusions of decomposing organised matter (whence their name *Infusoria* is derived), they are, as already stated, diffused in greater or less degree, through almost all the fluid masses upon the earth's surface; and thus the animalcules found in such infusions, may be regarded as but a minute specimen of those at present existing in the waters, which cover so large a portion of our globe. But they are not confined to a fluid medium. There are many species whose natural habitation is mud; and others which aggregate together in masses, so as themselves to form a kind of earth, which only requires a moderate amount of moisture to preserve them alive. The extraordinary discoveries of Ehrenberg, presently to be mentioned, in regard to the existence of the remains of Polygastrica in a fossil state, led him to make a series of experiments upon their production in this curious condition; and he has fully succeeded in manufacturing *living* earth, in large quantities. This corresponds precisely with the *Tripoli* which occurs as a mineral in large beds, and which is important to Man from its use in the arts; and, according to Ehrenberg, a small rise in the price of Tripoli would make it worth while to manufacture it from the living animals, as an article of commerce. There are many species which are capable of maintaining a torpid existence, in earth dried up by the summer sun; and they are thus raised into the air, in countless myriads, in the form of the most finely-divided dust. Perhaps if received into a moist atmosphere, they may even revive and grow under these circumstances; for they are sometimes deposited again in large masses. In 1687, a great quantity of a black paper-like substance fell, with a violent snow-storm, from the atmosphere in Courland. A portion of this substance, preserved in the Berlin Museum, has been microscopically examined by Ehrenberg; and has found it to consist entirely of an organic mass of *Confervæ*, matted together, and including twenty-nine species of Infusoria, all of which occur in the neighbourhood of Berlin. It is not unlikely, however, that this mass was originally formed at the surface of a marsh, and was raised altogether by a storm;

since others of similar character have been found in such situations. One of these, formed as a green slime on the surface of stagnant water covering a meadow, deposited itself when the water was slowly let off; and it then became quite colourless, resembling white dressed glove-leather, whence it received the name of "Meadow Leather." When examined with the microscope it was found to consist, like the Meteoric Paper, of *Confervæ*, intermixed with the siliceous remains of *Infusoria* of various kinds. A similar mass of greater extent and thickness, was recently found covering the ground after an inundation, near Sabor in Siberia. This extended over a surface of several hundred square feet, and was of a consistence resembling flannel. It consisted, like the Meteoric Paper, and Meadow Leather, of a matted mass of *Confervæ*, interwoven with fifteen species of Infusoria, and some shells of the *Daphnia* (water-flea).

1133. It is in considering the accumulations of these remains, however, which have taken place in successive ages, and which have come down to us, sometimes in the form of large distinct beds, sometimes as constituents of others, that we are the most impressed with the vast amount of animal life, to which they owed their origin. Even the accumulations of this nature which are at present in progress of formation, startle us by their magnitude, when we consider the extreme minuteness of the organised structures of which they are composed. Ehrenberg states that, in the Public Garden at Berlin, workmen were employed for several days in removing in wheelbarrows masses of earth, which, on examination, were found to consist entirely of *Infusoria* already becoming fossilized. These had probably lived and increased, much in the condition in which their remains were found. In other instances, a deposit of mud is taking place at the bottom of lakes and marshes containing the living animals; and thus an accumulation is going on, which will possess something of the *laminated* structure exhibited in all masses slowly deposited in water. Of this fact, abundant instances are related by Ehrenberg as occurring in various parts of Europe. Such a deposit has also been found by Professor Bailey at West Point, New York, at about a foot below the surface of a peat bog; it was eight or ten inches thick,

and probably several hundred square yards in extent; and it was wholly made up of the siliceous shields of *Bacillariæ.* A similar deposit has been recently discovered by Dr. Drummond in Ireland. The author has seen water, brought from a lake in the island of St. Vincent, crowded with the shields of races of *Naviculæ* at present inhabiting it; and a thick layer of mud, which is being deposited at the bottom of the lake, is almost entirely composed of them.

1134. Some species of these Animalcules especially prefer waters impregnated with iron; and have the power of separating the metal from its solvent, and incorporating it into their own structures. Hence originates a soft yellow ochreous substance, called Marsh Ochre or Meadow Earth, which is found in large quantities every spring in the marshy neighbourhood of Berlin, covering the bottom of ditches, and the hollows left by the footsteps of animals. The iron may be separated from the siliceous shields of these Animalcules, which retain their form after it has been extracted; and, after the death of the Animalcules, the iron forms a nucleus, to which more is attracted from the solution in which they have lived. Similar ferruginous and siliceous remains of Infusoria, have been found in ochreous substances brought from the Ural mountains and from New-York; and also in a yellow earthy substance formed on the surface of the mineral water of the salt works at Colberg, which is used for iron-colour in house-painting. These discoveries, therefore, open an immense field for inquiry, into the constitution of the larger beds of ferruginous matter, deposited at former periods, going back from those which are known as bog-iron-ore.

1135. Of the more recent among such deposits of these Infusorial exuviæ, as may be regarded as fossil, are those of the *Berghmehl*, which is found in small masses in various parts of Europe, and consists of a kind of siliceous earth mixed with animal matter. On account of its nutritious qualities, this has been employed as an article of food, especially in Sweden, where it is very abundant in some localities. When microscopically examined, it is found to be entirely composed of the remains of animalcules, the siliceous shields of which inclose the origi-

nally soft tissue of the body in a dry state. By exposing this substance to a white-heat, the animal matter is driven off, and the delicate siliceous shields are obtained in a perfectly unaltered state. By this process it is found that about 25 per cent. of dry animal matter is contained in the earth. In some of these collections, the animalcules are of large size, their siliceous shields measuring as much as $\frac{1}{1000}$ of an inch in length. In the older strata of the tertiary formation more extensive deposits are found. One of the most remarkable of these, is that which is termed the *Polierschiefer* (polishing slate) of Bilin; this supplies the *tripoli* used by artisans in metal for polishing their work, and also the fine sand employed to form moulds for casting small articles of Berlin iron. For these purposes, Ehrenberg estimates its consumption in Berlin only, at from 50 to 60 cwt. yearly. This deposit occupies a surface of great extent, probably the site of an ancient lake, and forms slaty or laminated strata of fourteen feet in thickness. It is almost entirely composed of an aggregation of the siliceous shields of one of the minute forms of fossil Infusoria, the *Gaillonella distans.* The length of one of these is about $\frac{1}{288}$ of a line, which is about $\frac{1}{6}$ of the thickness of a human hair. About 23 millions of animalcules are contained in a cubic line of the Polierschiefer, and 41,000 millions in a cubic inch. A cubic inch of the Polierschiefer weighs 220 grains; and thus 187 millions go to a grain; or the siliceous shield of each animalcule may be regarded as weighing about the $\frac{1}{187000000}$ of a grain. The minuteness of these is surpassed by that of the Animalcules of the Marsh Ochre, which are only $\frac{1}{1000}$ of a line in diameter, $\frac{1}{121}$ part of the thickness of the human hair, $\frac{1}{3}$ of the diameter of a globule of the human blood. A cubic line of such animal iron-ochre would thus, in the same proportion, contain 1000 millions, and a cubic inch upwards of 1,000,000,000,000 of living beings

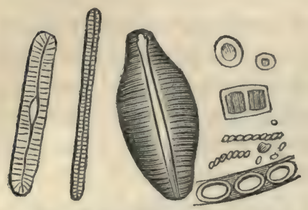


FIG. 627.—FOSSIL REMAINS OF ANIMALCULES, FORMING TRIPOLI.

1136. In the Polierschiefer are found hard nodules of an Opaline character, which are pretty obviously composed of the siliceous shields of *Gaillonellæ*, united together by an inorganic cement, formed by the partial solution of some portions of the mass,—just in the same manner as compact limestones may be formed by the solidification of coral-sand (§ 1105). By the similarity in the character of these nodules to the Semi-opal of older formations, Ehrenberg was led to examine various specimens of this mineral; and he has succeeded in obtaining distinct organic remains of animalcules from their interior: so that it is probable that its nodules have been entirely composed, like those of the Polierschiefer, of the siliceous remains of Animalcules, which have subsequently undergone a partial metamorphosis. In the white and opaque bands of Chalk Flints, he has also found spherical bodies, which he considers to be of organic origin; these are especially abundant in the white siliceous crust which forms the exterior of the flints, and in the mealy siliceous powder sometimes found within their cavities. As the same flints often exhibit remains of the structure of Sponges, it would not seem improbable, that the Animalcules may have been drawn into the canals of the Sponge whilst alive, and may have thus been imbedded within it. It is not a little interesting to remark that, whilst the microscopic contents of more recent strata are all fresh-water Infusoria, those of the chalk are species which must, or at least can, live in the waters of the ocean. It is also a curious and important fact, that, of about eighty species of fossil Infusoria, discovered in various strata, almost half are species which still exist in the waters; and thus these forms of life, so long overlooked as invisible specks of brute matter, have a constancy and durability through the revolutions of the earth's surface, which is denied to animals of more conspicuous size and higher organisation, the continuance of whose existence depends upon a greater variety of favourable conditions.

CHAPTER XXVI.

OF THE CLASS OF PORIFERA.

1137. THE lowest of the classes usually comprehended under the Radiated type, is one whose claim to a place in the Animal Kingdom must be regarded as very doubtful. Not only is the *radiated* disposition of parts altogether wanting, but even that definiteness of form is absent, which so peculiarly distinguishes the higher groups of Animals from the members of the Vegetable Kingdom. The absence of characteristic structure does not extend to external form alone; it is equally remarkable in the internal arrangement of the parts, of which these beings are composed. There is no stomach or digestive cavity for the reception of food,—no nervous system or organs for sensation or locomotion,—and nothing beyond the very simplest apparatus for reproduction. In the vital actions performed by these beings, there is nothing distinctly characteristic of an Animal nature. No movements can be observed, either in the whole structure, or in portions of it; neither is there any indication of the possession of sensibility. In fact, the only *obvious* vital action which can be observed in their ordinary state, is a movement of fluid through their channels; and this does not differ, except in rapidity, from what may be seen in Plants.

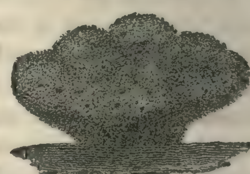


FIG. 628.—SPONGE.

1138. There can be little question, then, that if the Class PORIFERA, consisting of the Sponges and their allies, is to be ranked in the Animal creation, the lowest place in the scale is justly assigned to it; since the beings which it contains exhibit so few indications of any but *organic* life, that it has been, and perhaps still may be, doubted, whether they should not

rather be assigned to the Vegetable Kingdom. Perhaps the strongest argument for their Animal nature, is to be found in the resemblance of their structure to a part of that, which constitutes beings whose animal character is undoubted. The group of *Alcyonia* (§ 1087) consists of Sponges with Polype-mouths; and in the growth of these structures, the spongy mass is first formed, the polypes not appearing until a subsequent period. The substance commonly known as *Sponge* is in reality but the framework or skeleton of the being in its living state. When growing beneath the waters it inhabits, this framework is covered by a living flesh, which not only envelopes its exterior, but lines all the canals that ramify through its substance. This enveloping flesh is so extremely soft, as to drain away when the mass is removed from the water, like the white of an egg, or the vitreous humour of the eye; hence its existence was for a long time overlooked, and the mode in which the harder texture grows was not at all understood. It is principally to the observations of Dr. Grant (which have been confirmed by other naturalists), that we owe the elucidation of the real character of the spongy structure, and of its concern in the actions performed in the living state.

1139. When we examine the exterior of a piece of common Sponge, we observe that it is covered with minute orifices or *pores* (whence the name which has been given to the class), thickly set together; and that larger openings are disposed at intervals amongst these. If these larger orifices, or *vents*, be traced into the substance, it will appear that they are the mouths of canals or vessels which ramify through it; these have definite walls formed by the firm tissue of the sponge, but perforated with a large number of orifices, connecting them with the spaces that lie between their net-work of branches. The pores, on the other hand, open into a less regular arrangement of small tubes and cells, of which the spongy mass is principally composed. These spaces are produced by the interlacement of the fibres that form the solid framework; they communicate with one another throughout the mass; and the canals seem to take their origin from the midst of them, arising by small tubes

which unite into larger ones, and these again meeting to form the wide channels which terminate in the vents. If, after making such an examination of the structure of the Sponge, we tear a small portion of it into fragments, its fibrous nature becomes very apparent. If we submit these fragments to a low magnifying power, it is perceived that they form a complete network, inosculating with each other in every direction. By applying a higher power, it is ascertained that they are of tubular structure. In the *Common Sponge*, the whole framework is composed of these tubular fibres, which in some parts are set very closely together, whilst in others they are loosely arranged. They consist entirely of an organic texture, rather approaching the *horny* substance of Animals (as is made evident by the smell emitted on burning it), than anything which we meet with in the Vegetable Kingdom; and it is to their elasticity, that the Sponge owes those properties, which make it so useful to Man.

1140. In other forms of the group, however, spicula of earthy matter are disposed amongst these; which add to the firmness of the structure, and diminish its elasticity, according to the amount in which they are present. These spicula are in some instances composed of carbonate of lime; in others they consist of pure silex; and their form varies according to the material. The earthy spicula are disposed at intervals through the whole mass; but they are especially abundant in the neighbourhood of the canals, and around the external orifices, both of these and of the pores. In fact each of these orifices is strengthened by a regular framework of spicula disposed around it; and a high magnifying power enables us to see, that across the entrance to the pores, there is also a very delicate membranous network, which acts as a filter or sieve, preventing the entrance of improper particles along with the fluid which is drawn in through them. In many instances, the sharp ends of the spicula project from the surface of the Sponge, as if for its defence.

1141. When Sponges are examined in their living state and natural condition, a constant and rapid stream of water is seen to issue from the larger orifices or vents. This stream is made apparent by the movement of the minute particles contained in

it, and by the disturbance of those which may be floating in the surrounding fluid. On the other hand it is easily made apparent,

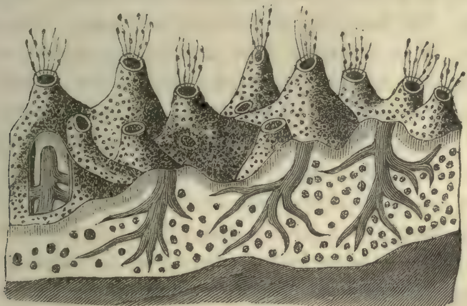


FIG. 629.—SECTION OF LIVING SPONGE.

that water is as constantly being imbibed through the minute pores; and that, after traversing the smaller cavities of the spongy structure, it finds its way into the canals through which it is expelled. Some such absorption must take place, to supply the fluid incessantly discharged through the vents. It is impossible to assign a cause for this movement; no cilia have been discovered in any part of the adult animal; and the tissues are altogether possessed of so little contractility, that it is difficult to suppose the fluid propelled through the tubes by any mechanical influence on their part.

1142. The nutrition and growth of the Sponges appear to depend entirely, then, on the water which enters the pores, on the substances which it holds in solution, and on the minute particles suspended in it. The entrance of any but the smallest solid substances is prevented by the network, which has been described as stretching over the pores. From these, and from the water itself, the animal tissue appears to derive the materials of its nourishment; and the siliceous and calcareous substances must be separated by it, from the state of solution in which they exist in the surrounding fluid. When the large quantity of this fluid, which passes through the canals of the Sponge in a short time, is taken into consideration, it is not difficult to account for the derivation of these ingredients from it; although they often

exist in such minute proportion, as scarcely to be recognised by the chemist. Not only does this circulation of fluid answer the purposes of nutrition, but it is subservient also to the process of excretion. On watching the currents of water that issue from the vents, it is observed that minute flocculent particles are incessantly detached and carried out by them; these appear as if they were the residue of digestion, or pellicles excreted from the body and thrown off from the surface of the internal canals. Sometimes the vents are all on one side, whilst the absorbent pores are on the other; and in one interesting species of a bottle-like form, the *Leuconia compressa*, the pores are entirely situated on the outside, and the vents on the interior, so that a single constant and rapid current of fluid proceeds from the mouth, which is contracted into rather a narrow orifice.

1143. This movement of fluid through their tissue seems to be almost the only action, that proves the existence of life in these simple beings. No obvious contraction can be perceived when they are touched or irritated. They may be punctured or cut with sharp instruments, pierced with red-hot wires, or torn into fragments; and yet no change of form, or other evidence of sensibility, can be perceived in them. The parts which are unimpaired will continue to present the same phenomena as before; and no injury seems to have any influence, beyond the portion immediately affected by it. Nevertheless some observers maintain that a shock, affecting the whole mass alike, does produce an evident effect upon it. This has been particularly noticed in the *Spongilla*, or River-sponge. When allowed to fall into water from the height of a few inches, or when the stage of the miscroscope is struck, the tubular prolongations on which the vents are situated contract very sensibly, until the orifice is nearly closed, and projects but slightly. It has also been noticed that these projecting orifices vary considerably in their form at different times, even within short intervals, and when no external cause has influenced them. Some Naturalists state, moreover, that, although no sensible contractions and dilatations can be *seen* in the whole mass, a peculiar sensation is *felt* when the hand is placed upon a specimen still under water. This sensation is of a tingling character, and appears due to some

movement in the individual particles, of which the flesh of the Sponge is composed.

1144. The *Sponges* may be multiplied by artificial division; each portion then becoming a new individual, like the separated buds of Plants. But no such division appears to occur in their natural state; and they are reproduced by the separation of minute spore-like bodies from the gelatinous portion of their tissue. This process takes place, in the species of our own coast, at the earlier part of winter. At that period, the little reproductive bodies, or *gemmules*, first appear as minute opaque yellow points, irregularly distributed in the substance of the body, and usually at a distance from the surface. As their development proceeds, they become larger and more opaque, and present a regular oval form. They then protrude from the gelatinous lining of the canals, into their cavity; and it is seen that the protruding portion is covered with cilia, which are in active operation. After a further period, they become altogether detached from the parent structure, and swim forth, by means of the cilia, through the large orifices in which the canals terminate. In this condition they appear as egg-shaped particles of gelatinous matter, the greater part of whose surface is covered with cilia; but the smaller end, by which they were previously attached, is left bare. By the vibration of these cilia they swim about for some time, very much in the manner of Animalcules. Their motions are equal, smooth, and gliding; and they appear to be influenced by each others' proximity. When they approach near to each other, as is sometimes observed, they often arrest their course, and swim for a short time round each other. They appear by these movements to seek a place adapted to their development; and to this they seem partly guided by the influence of *light*, which they seek to avoid. The nature of the site chosen varies with the species. Some incrust the surfaces of loose stones or shells; others stand erect upon a solid base; and others hang from the under surfaces of projecting rocks. Sometimes earthy spicula may be observed in the gemmules, before they have attached themselves; and in those species which possess them in the perfect form, they always appear within a short time after they are fixed. No trace of internal canals, how-

ever, can be discovered at this period; and the formation of these does not begin, until after the gemmule has completely changed its condition.

1145. When it attaches itself to any surface, the gemmule adheres by its small extremity, and the cilia continue their action for some little time afterwards, as if to clear a proper site for the extension which is immediately to take place. The gemmule then spreads itself out into a flat transparent film; and the earthy or horny fibres soon begin to appear in them. They then exhibit minute depressions on their surface, which gradually become deeper, so as to form canals penetrating into it; these unite with each other, and send out ramifications through the whole structure as it extends; and thus the spongy mass is at last fully formed. The spicula and fibres, which at first appeared to be confusedly developed in the gelatinous growing membrane, then manifest great symmetry and method in their distribution, with relation to the pores, canals, and vents. The existence of this locomotive power in the gemmules of Sponges, cannot of itself be regarded as an unequivocal proof of their Animal nature; since, as it has elsewhere been shown (Veget. Physiol. § 424), the sporules or reproductive granules of the Algæ are equally active before fixing themselves. But in their possession of *cilia*, which are not known to exist in the Vegetable kingdom, and in the parallelism between their subsequent development and that of the gemmules of the Polypifera, there exist reasons in support of their Animal character, though this is very feebly manifested.

1146. The Geographical distribution of the Porifera is very extensive; indeed it may be said to be almost universal. Every coast, from the Equator to the highest Polar regions, furnishes some kinds of Sponge; but they exist in much greater abundance in warm latitudes than in cold, and they attain also a much greater size. They are all, of course, inhabitants of the water only, and if long removed from it they lose their vitality; but there are many species, which seem able to bear exposure to the air between the intervals of the tide, appearing to flourish equally well in deep water, or at a level which is occasionally left dry.

1147. There is some difficulty and uncertainty in regard to the Fossil remains of Sponges; but it is probable that these have come down to us from a very remote period of the earth's history, and it may be reasonably supposed that Sponges were among the earliest inhabitants of the ocean. These remains are found in two states. Sometimes the whole tissue has been permeated by siliceous or calcareous matter; so that, on the mass being broken, its internal structure is very evident. In other instances we have only the *casts*, which have been formed by the subsequent filling-up, with stony matter, of the cavities left by their decay. There is reason to believe that, in the Sponges of ancient date, the siliceous spicula must have predominated; for we find their fossil remains almost always silicified, even in calcareous rocks. Thus, in the Chalk (in which they greatly abound) all the remains of Sponges present the character of *flints*. Some of these flints, when broken, exhibit very beautifully the structure of the Sponge; and others possess only its external form. Now, many of the Chalk fossils are infiltrated with carbonate of lime, and not with flint; and this even when associated with Sponges. In the same flint-nodules which envelope Sponges, the shells of the Echinus (§ 1002) are found converted into crystallized carbonate of lime, and dense shells of Mollusca are scarcely at all changed. It is evident, then, that some peculiar attraction for siliceous matter exists in the Sponges; and this is readily explained upon well-known chemical principles. If in a saturated solution of two salts, a crystal of one of those salts be placed, it will be increased by a crystalline deposit of its own composition; whilst the other salt will not form any deposit around it. If two organic structures, therefore,—one containing siliceous spicula, and the other calcareous crystals, be exposed to a fluid holding both these substances in solution, they will attract from it their own ingredient.

"O LORD, HOW MANIFOLD ARE THY WORKS; IN WISDOM HAST THOU MADE THEM ALL."

APPENDIX.

ON THE INSTINCTS OF SOCIAL INSECTS.

A GENERAL account has been elsewhere given (ANIM. PHYSIOL., Chap. XIV.) of the habits and instincts of the Hive Bee; and a similar sketch will be here given of the History of the *Termites* or White Ants, and of that of the Common *Ants*.

The *Termites*, or White Ants, belong to the Order Neuroptera (§ 675); and are the only true *social* insects contained in that group. Next to the Locusts, they may be reckoned the most destructive Insects known to Man; since not only articles of food, but clothing, fences, trees, and even houses, fall before their devouring jaws. As they are confined, with scarcely any exception, to tropical climates, we are only acquainted with their ravages by the reports of travellers who have visited those regions; but these reports are such, as we may fully trust to.—The Termites live in immense communities, consisting of kings and queens, soldiers and labourers. The kings and queens are perfect insects, male and female; and their office is solely to increase their kind. The soldiers appear to be the *pupæ*, stopped in their development, so as never to possess wings or to acquire the reproductive organs; it is their office to attack every object or living thing, that in any way injures or endangers the safety of the nest; and this duty they perform with the most reckless bravery, the labourers retiring within the nest during the time of danger. The labourers are probably to be regarded as the *larvæ*, alike checked in their development; their offices are manifold,—their duty being to take the eggs from the queen as fast as she lays them, to convey them to the nurseries and to tend them until hatched, and to feed the young, store provisions, build the nest, repair damages, and perform every kind of labour requisite for the good of the community,

The nests of the Termites are so numerous all over the island of Bananas and the adjacent Continent of Africa, that it is scarcely

possible to stand upon any open place, such as a rice-plantation or other clear spot, where one or more of these buildings is not to be seen within fifty paces. In some parts near Senegal, as mentioned by Adanson, their number, magnitude, and closeness of situation, make them appear like the villages of the natives. These buildings are usually termed "hills" from their outward appearance, which is that of little hills, generally pretty much in the form of sugar-loaves, and about ten or twelve feet in height. These hills continue quite bare until they are six or eight feet high; but in time become, like the rest of the earth, almost covered with grass and other plants; and in the dry season, when the herbage is burnt up by the rays of the sun, they somewhat resemble very large hay-cocks. The exterior of the building consists of one large shell or domed wall; which is large and

NESTS OF TERMITES The large nests, of which one is cut open vertically to show the interior, are those of the *Termes bellicosus*. The small nest (*a*) in the tree, is that of the *Termes arborum*; and at *b* is seen the arched gallery, by which it communicates with the ground.

strong enough to shelter the interior from the weather, and to protect the inhabitants from the attacks of most of their enemies. It also serves to collect and preserve a regular degree of genial warmth and moisture; which seems very necessary for hatching the eggs and cherishing the young ones. The interior is divided, with great regularity and contrivance, into a great number of

apartments; some of which are intended for the residence of the kings and queens, and for the rearing of their numerous progeny; whilst others serve as magazines, and are always found well filled with stores and provisions.

These hills make their first appearance above ground, by a little turret or two, in the shape of sugar-loaves; which only rise to the height of a foot, or a little more. Soon afterwards, at some little distance, while the former are increasing in height and size, the Termites raise others; and so go on increasing the number, and widening them at the base, till their works below are covered with these turrets, which they always raise the highest and largest in the middle; they then, by filling-up the intervals between each turret, collect them, as it were, into one dome. They are not very curious or exact about these turrets, except in making them very solid and strong; and when, by the junction of them, the dome is completed (for which purpose the turrets answer as scaffolds), they take away the middle ones entirely, except the tops, which, joined together, form the crown of the cupola; and they apply the clay to the building of the works within, or to the erection of fresh turrets for the purpose of raising the hillock still higher.

The *royal chamber*, so called on account of its being adapted for, and occupied by, the king and queen, is situated near the centre of the hillock. It resembles the shape of an egg cut in half lengthways, and is at first not above an inch in length; it is afterwards increased, however, to six or eight inches, or even more, in proportion to the size of the queen (§ 675). The floor and roof of this chamber are very solid, and are composed of hardened clay. Its walls are pierced by several entrances, which will admit the soldiers and labourers, but which are not large enough to allow the king and queen (who is, at full size, a thousand times the weight of a king) to pass out. It is surrounded on all sides by a series of chambers, which may be called the royal apartments, and which are occupied by the soldiers and labourers that guard the pair, on whose safety depends the happiness, and probably even the existence, of the whole community. These apartments, being connected together by openings and passages, form an intricate labyrinth, which extends a foot or more in diameter from the royal chamber on every side; and they are surrounded by the magazines and nurseries. The former are chambers of clay; and are always well filled with a kind of provisions, which appear to consist of the gums or other thick juices of plants. The nurseries, which are so called because they

always are found to contain eggs and young ones, are entirely composed of wooden materials, seemingly joined together with gums. These are placed as near as possible to the royal apartments. When the nest is in the infant state, they are close to the royal chamber; but as, in process of time, the queen enlarges, it becomes necessary to enlarge this chamber for her accommodation; and as she then lays a greater number of eggs, and requires a greater number of attendants, so is it necessary to enlarge and increase the number of the adjacent apartments; for which purpose, the small nurseries that were at first built are taken to pieces, and are rebuilt a little farther off. The nurseries are inclosed in chambers of clay, like those which contain the provisions, but much larger. In the early state of the nest they are not larger than a hazel-nut; but in old hills, they are often as large as the head of a child a year old. Under the dome is a large open space, which is surrounded by three or four large arches of a somewhat gothic form; this space may perhaps be intended to equalise the temperature of the chambers below, by preventing either the sun or the cold air from at once affecting the latter.

Beneath the lowest apartments are found a set of large passages, which communicate with all the chambers of the interior, and also with the galleries that diverge from the nest in various directions. These passages, which are thickly lined with the same kind of clay as that of which the hill is composed, ascend the inside of the shell in a spiral manner; winding round the whole building up to the top, and intersecting each other at different heights, and communicating with the various chambers by galleries branching out from them. From the bottom of these are several large galleries, which lead downwards into the ground below, sometimes to the depth of three or four feet; these are mines or quarries, whence the Termites obtain the fine gravel and clay, which they work up in their mouths to the consistence of mortar; and then use in the construction of their buildings. Other galleries extend horizontally beneath the ground, at a small depth below its surface, to a great distance. Sometimes these passages cannot be continued under ground in the required direction; and the Termites then make pipes or covered-ways along its surface, composed of the same materials with the nests. These they continue, with many windings and ramifications, for great lengths; and they construct, where it is possible, subterranean pipes running parallel with them, into which they may sink and save themselves, if their galleries above ground are

destroyed by violence, or the tread of men or animals alarm them. When a person accidentally enters any solitary grove, where the ground is pretty well covered with their arched galleries, they give the alarm by loud hissings, which may be distinctly heard at every step; soon after this, their galleries may be searched in vain for the insects; but little holes are found, just large enough to admit of their escape into the subterraneous roads. These galleries are of sufficient size to allow the Termites to pass and repass without stopping each other (though there are always numerous passengers), and to shelter them equally from light and air, as well as from their enemies,—of which the Ants, being the most numerous, are the most formidable. If the Termites are dislodged from their covered ways, the various species of Ants (which are probably as numerous above ground as the Termites are in their subterranean passages) instantly seize and drag them away to their nests, to feed their young brood. The Termites are, therefore, exceedingly solicitous about preserving their covered ways in good repair; and if one of these be demolished for a few inches in length, it is wonderful how soon they will rebuild it. At first, in their hurry, they run into the open part an inch or two, but stop so suddenly that it is evident they are surprised; for though some will run straight on, and get under the further part of the arch as speedily as possible, most of them run back as fast, and very few will venture through that part of the gallery which is left uncovered. In a few minutes they may be seen engaged in rebuilding the arch; and even if three or four yards of their gallery have been destroyed, it will be restored by the next morning, and will be found to contain numerous Termites passing along in both directions. If the gallery be several times destroyed, they will at length seem to give up the point, and build another in a different direction; but if the old one led to some favourite plunder, they will rebuild it again in a few days; and unless the nest be destroyed, they will never totally abandon their gallery.

The galleries of the Termites are often carried beneath the foundations of houses and store-houses, at several feet below the surface; sometimes they rise through the floors; but they are frequently continued in the interior of the posts of which the sides of the buildings are composed, following the course of the fibres to the top, and having lateral perforations or cavities here and there. While some of the Termites are employed in gutting the posts, others ascend from them, entering a rafter or some other part of the roof, in search (as it would seem) of thatch,

which is their favourite food. If they find it, they bring up wet clay, and build galleries through the roof in various directions, as long as it will support them. In this manner a wooden house is speedily destroyed; and all that it contains is, at the same time, subjected to the ravages of these destructive insects. In carrying on this business, they sometimes appear to find, by some means or other, that the post has a certain weight to support, and then, if it is a convenient track to the roof, or is itself a kind of wood agreeable to them, they bring their mortar; and, as fast as they take away the wood, replace the vacancy with that material, which they work together more closely and compactly than human strength or art could ram it. Hence, when the house is pulled to pieces, the posts formed of the softer kinds of wood are often found reduced almost to a shell; and almost all of them are transformed from wood to clay, as solid and hard as many kinds of free-stone used for building in England.

Of the true *Ants*, which belong to the Order *Hymenoptera*, a general description has been already given (§ 694); but it remains to notice some of the chief points in the structure of their habitation, and in their social economy. As among the Termites, there are four orders in the community,—the perfect males and females, the workers, and the soldiers; the workers and soldiers, however, cannot be regarded as either larvæ or pupæ, since they undergo the regular metamorphoses; but they have neither the wings nor the reproductive organs developed. As among the other social Hymenoptera, they are *neuters*, that is, of no sex; but they most nearly approach the female. The soldiers of the Red Ants of this country are nearly three times the size of the workers, and their heads are larger in proportion; those of the Yellow Ant are about twice the size of the workers. In describing the habitations of this race, it will be best to confine ourselves to the latter of these species, which is very abundant in our own country. Their hillocks are apparently made in a much less elaborate manner than the dwellings of the Termites; but they are not less perfectly adapted to their required object. They are composed of bits of stubble, fragments of leaves, small stones, splinters of wood, &c., which are collected by the Ants, and laid (as it might appear) promiscuously together; but although apparently a careless heap, the hillock is really a most ingenious device for evading the effects of wind and the attacks of enemies, and yet more especially for receiving and husbanding the heat of the sun. Its exterior always presents the appearance of a dome;

and from its summit a number of avenues, carefully excavated like tunnels, lead downwards into the interior,—the number of them depending on the population and extent of the nest. Their external apertures are of varied size; there is sometimes a principal one at the top; but there are usually several, of unequal size, which are surrounded by passages arranged with great regularity. In the habitations of many species of Ants, we never find an aperture of sufficient size to allow the entrance of enemies or the passage of rain-water; the dome being closed on every side, and having only one aperture near the base, which is not unfrequently continued into a serpentine gallery many feet in extent. With the Yellow Ants, however, it is quite different. They stand in crowds on their nests during the day, and seem quite fearless of any disturbance to the interior; and at night, before retiring to the bottom of their habitation, they close all the apertures with the greatest care. This curious fact was first discovered by Huber, to whom we owe so much of our knowledge of the economy of Bees and Ants. On closely watching the appearance of one of these nests, he found it undergoing an hourly change; so that the apertures, so spacious in the middle of the day, gradually diminished in size towards the evening, and at night entirely disappeared; the dome being then closed in every part, and all the Ants being concealed within. In order to accomplish this, the Ants draw little bits of wood into the openings, placing them across the entrance, and sinking the ends in the covering of the hill; they then fetch others, laying them across the first, and so continue selecting other pieces, smaller and smaller as the work advances towards its accomplishment; and finally close the opening with bits of dried leaves, and similar materials.—In the morning, a few Ants may be seen wandering about the exterior of the nest,—the numbers gradually increasing, as others emerge from the interior under the little roofs formed at the entrance of each avenue; and these soon set to work, and begin to clear away the barricades. This employment continues for hours, until at length the apertures are sufficiently extended; and the materials used in closing them are distributed over the exterior of the nest. This is a daily labour, unless it rains, or the morning threatens rain; and if rain come on after it has been performed, they hasten to close the apertures as at night.

The dome contains a number of spacious chambers, communicating with each other by galleries; these chambers, however, are low, irregular in figure, and carelessly constructed; but they are convenient, nevertheless, for the purpose for which they are

constructed,—that of containing the larvæ and pupæ at certain hours of the day. The eggs, when deposited by the female or queen ant (who drops them at random in her progress through the nest), are taken charge of by the workers; who immediately seize them and carry them in their mouths, in small parcels, and lay them in heaps in separate apartments. They constantly tend them until they are hatched, incessantly turning them backwards and forwards with their tongues for the purpose of moistening them, without which they would come to nothing; and it must be to the moisture thus imparted to them, that the great enlargement of the eggs is due, which has been constantly noticed previously to the hatching of the larvæ. The workers frequently remove the eggs from one quarter of the nest to another, as they require a warmer or a cooler, a moister or a drier atmosphere; and at intervals they brood over them, as if to impart to them a genial warmth. When the larvæ come forth, the workers are almost constantly engaged in supplying their wants and forwarding their growth. Every evening, an hour before sunset, they regularly remove the whole brood (as well as the eggs and pupæ) to cells situated lower down in the earth, where they will be safe from cold; and in the morning they as constantly remove them again towards the surface of the nest,—unless there is a prospect of cold or wet weather, in which case they do not remove them. When the rays of the sun first strike upon the nest, a most animated scene takes place. The Ants on the exterior are the first to feel the influence of the warmth; they enter the nest, run along the avenues and galleries to the various chambers, and communicate the intelligence to every ant they meet,—tapping their fellows gently with their antennæ, or, if this be not attended to, biting them severely with their mandibles. At last the whole colony seems to partake of the excitement, and each labourer then carefully takes a larva or a pupa in his mouth, conveys it through all the winding passages to the outside, and places it in such a position as to receive the rays of the sun. The larvæ and pupæ are seldom exposed to the full rays of the sun for a longer period than fifteen or twenty minutes; they are then conveyed into little cells constructed on the exterior of the nest purposely to receive them, and are protected from the too great heat of the sun's rays, by a slight covering of chaff, stubble, or other light matter. As the heat of the sun decreases in the afternoon, the larvæ and pupæ are again fully exposed to it for a short season as before, and are then carefully returned one by one, through the almost interminable passages, each into the identical chamber

from which it was brought in the morning; and after this they are carefully fed by the workers, who nourish them with the food they have collected during the day.

When the larvæ have attained their full growth, they spin a cocoon, in which they remain as pupæ until the time of their final change. In this state they are commonly, but erroneously, known under the name of "eggs;" and being a favourite article of food with pheasants and partridges, they are eagerly sought after by persons who rear these birds from the egg. The cocoons containing the pupæ are of a long cylindrical form, and of a dirty white colour; and the contained animals are perfectly motionless. When ready to come forth as perfect Ants, they cannot, like most other Insects, set themselves free from their envelope; but they are dependent upon the assistance of the workers, who moisten it and cut it with their mandibles, and then gently draw forth the contained body. The greatest care is bestowed upon the winged Ants,—the perfect males and females,—on which the continuance of the race depends; these are most assiduously tended by the workers, who cleanse their bodies, extend their wings, supply them with food, and accompany them in their wanderings through the hive. A large number of the winged Ants are produced every season in each community; and they may be frequently seen in the autumn, covering almost the whole surface of the hillock. The greater number of these, however, perish in various ways; and only a small number remain, either to found new colonies, or to keep up the population of the parental residence. Sometimes the new colony is commenced by the queen alone: who excavates her future dwelling-place, and lays the eggs, feeds the larvæ, and tends the pupæ, without any assistance; but the workers that are first produced, then aid her in the requisite attentions to the subsequent progeny. In other instances, the queen falls in with a few workers, that have wandered, at this period of excitement, to an unusual distance from the nest; and if so, they unite their labours with hers.

The most remarkable fact connected with the history of Ants, is the propensity possessed by certain species to kidnap the workers of other species, and to compel them to labour for the benefit of the community, thus using them completely as slaves; and, as far as we yet know, the kidnappers are red or pale-coloured Ants, whilst the slaves are of a jet black. The time for capturing slaves extends over a period of about ten weeks, and never commences until the male and female Ants are about coming forth from the pupa state; and thus the marauders never

interfere with the continuation of the species. This appears to be a special adaptation of their peculiar instinct; for if the attacks were made on the nests of the Negro Ants, before those by whom the race is propagated are ready to issue forth, it must speedily become extinct.—When the Red Ants are about to sally forth on a marauding expedition, they send scouts to ascertain the exact position in which a colony of Negro Ants may be found; these scouts, having discovered the object of their search, return to their nest and report their success. Shortly afterwards, the army of Red Ants marches forth, headed by a vanguard, consisting of eight or ten Ants only, which is perpetually being changed,—the individuals which constitute it, halting, when they have advanced a little before the main body, falling to the rear, and being replaced by others. When they have arrived near the Negro colony, they disperse, wandering through the herbage, and hunting about, as if aware of the neighbourhood of the object of their search, yet ignorant of its exact position. At last they discover the settlement; and the foremost of the invaders rushing impetuously to the attack, are met, grappled with, and frequently killed by the Negroes on guard. The alarm is quickly communicated to the interior of the nest; the Negroes sally forth by thousands; and the Red Ants rushing to the rescue, a desperate conflict ensues, which, however, always terminates in the defeat of the Negroes, who retire to the innermost recesses of their habitation. Now follows the scene of pillage. The Red Ants, with their powerful mandibles, tear open the sides of the Negro Ant-hill, and rush into the heart of the citadel. In a few minutes each of the invaders emerges, carrying in its mouth the pupa of a worker Negro; which it has obtained in spite of the vigilance and valour of its natural guardians. The Red Ants return in perfect order to their nest, bearing with them their living burthens. On reaching the nest, the pupæ appear to be treated precisely as their own; and the workers, when they emerge, perform the various duties of the community with the greatest energy and apparent good-will; they repair the nest, excavate passages, collect food, feed the larvæ, take the pupæ into the sunshine, and perform every office which the welfare of the colony seems to require; in fact, they conduct themselves entirely as if fulfilling their original destination.*

* The details of this Appendix have been chiefly taken from Mr. Newman's very excellent "Familiar Introduction to the History of Insects."

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